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Repeated music listening
mapping the development of melodic expectations

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Repeated Music Listening: Mapping the Development of Melodic Expectations

by

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Abstract

It has long been asserted that the mind's predisposition to predict the future based on the past and present underpins the understanding and enjoyment of music. An oft-considered paradox in music psychology is that if a listener's thwarted expectations cause an emotional response, how does this occur even when a piece is familiar? This motivates two objectives that concern melodic expectations in response to repeated music listening: the first is to empirically investigate the changing interplay between varying sources of expectation in adult listeners, and the second examines how melodic expectations evolve as a result of 'typical' and 'atypical' development. Investigation is achieved by empirically examining the interaction between different forms of expectation proposed by zygonic theory: schematic, within-group and veridical. Adults, typically developing children, and children with high-functioning autism took part in two experimental sessions separated by one week. In each session, individuals rated their perceived pitch-by-pitch expectedness using a Continuous Response Measurement Apparatus in response to a 4 x repeated 26-note melody. Results show that the relationship between the three forms of expectation functions differently in each participant group. Adult listeners' schematic and within-group expectations remain consistent, despite a cumulative increase in veridical expectations. 'Typical' children base their expectations on absolute properties and pairs of notes at 6-8 years, on longer sequences of notes and connected groups at 9-12 years, and more complex relational structures at 13-17 years. This aligns with age-related changes in memory capacity and efficiency. Children on the autism spectrum demonstrate a local processing bias and an ability to process global melodic structure, but not in a cumulative way that is sensitive to repetition. This implies an atypical interaction between long-term and working memory. In sum, the present thesis demonstrates how the interplay between three sources of expectation is underpinned by differences in memory function in the context of melodic repetition.

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1 Literature review

The research reported here is motivated by the question: how is it that music listeners continue to experience repeated pleasure from listening to the same familiar pieces of music? The emergence of analogue and subsequently digital recording has enabled modern populations to purchase music in order re-experience it (Lacher & Mizerski, 1994; North & Hargreaves, 1997); songs that are already replete with repetition are encountered recurrently on the television and radio (Margulis, 2014), and it is estimated that 99% of musical experiences are familiar (Huron, 2006). Despite repeated exposure, listeners continue to listen to the same pieces throughout their lifetimes, which implies that repeated music listening gives rise to desirable outcomes that listeners wish to re-experience. Research highlights several overlapping psychological outcomes, including emotional pleasure (Schubert, 2009), entertainment and social regulation (Vastfjall, Juslin, & Hartig, 2012), affective self-regulation (Conrad, Corey, Goldstein, Ostrow, & Sadowsky, 2018; Saarikallio 2011), and affective and eudaimonic functions (Groarke & Hogan 2016). Schafer, Sedlmeier, Stadtler, & Huron (2013) reviewed more than 500 functions of musical use and distilled them down to the three functions of self-awareness, arousal and mood regulation, and social relatedness, into which emotional functions are integrated. Indeed, Juslin & Sloboda (2010) report that the most frequent reason for music listening is for the emotional pleasure that it evokes. The question follows, which cognitive processes underpin the continued pleasure that listeners glean from familiar music listening?

It is reported that responses to music are supported by neurological, biological and psychological mechanisms including brain-stem reflexes, rhythmic entrainment, visual imagery and associative episodic memory (Juslin & Vastfjall, 2008). One significant psychological mechanism that has received several decades of attention is that of expectation, whereby implications that are set up through the way that music is structured generate predictions that are affirmed or denied. In this way, music presents an irresistible soundscape of predictability and surprise that draws the listener in again and again (Meyer, 1956; Narmour, 1990, 1992). The importance of expectations for the music listening experience has since been supported by experimental research (for example, Cuddy & Lunney, 1995; Krumhansl 1995a, 1995b; Schellenberg 1996, 1997), and several models of music cognition which hold expectation at the core (Huron, 2006; Larson, 1997: Larson & Hatten, 2012; Lerdahl & Jackendoff, 1983; Narmour, 1990, 1992; Margulis, 2005; Ockelford, 2006, 2012; Pearce & Wiggins, 2006, 2012). Much musical expectancy research demonstrates that various forms of expectation reside in different memory systems, which has been regarded as resulting in the experience of savouring 'surprising' musical moments (Huron, 2006; Ockelford & Grundy, 2014). Of significance is David Huron's book, *Sweet Anticipation: Music and the Psychology of Expectation* (2006) wherein he presents his ITPRA (imagination, tension, prediction, reaction, appraisal) model of expectation that stems from physiological and psychological processes, demonstrating that expectation pervades all aspects of music cognition and provides a foundation upon which musical understanding and thus music-induced pleasure can exist. Huron emphasises that his aim is to describe psychological processes involved in musical experience, and that although expectations do evoke emotions, he prefers to describe how expectations produce pleasurable rather than emotional responses, since "no one would bother about music" if it did not induce pleasure, yet emotional responses to music require a more comprehensive and complex discussion than what is proposed by the ITPRA model alone (Huron, 2006, p. ix). He continues “Pleasure does not preclude effort. Minds need to reach not simply grasp” (Huron, 2006, p. ix), hence, pleasure still arises from active mental processes such as expectation. Likewise, the current study focuses on the psychological process of expectation but draws on the idea that musical re-listening is a common activity that listeners engage in for pleasure. Although some literature on musical expectation is motivated by *emotional* responses (e.g. Meyer, 1956) the inclusion of such research in this thesis is key for explaining the cognitive processes involved in musical expectation.

Since expectation is a significant aspect of musical understanding and is thought to play a key role in the steering of pleasurable responses to music, investigating how expectations evolve during repeated music listening may shed some light on why continued pleasure during repeated music listening is possible. This spurs the present thesis’ aim and objectives which are presented in the following section.

1.1 Research aim and objectives

The overall aim for this thesis is to empirically investigate the role that melodic expectations play in the perception of familiar music as a result of ‘typical’ and ‘atypical’ development, where development refers to learning and cognitive development. This will be achieved by comparing the melodic expectations of populations with differing developmental trajectories, namely typically developing adults, typically developing children, and children with high-functioning autism. The conceptual framework that underpins the aim, objectives, research questions and analysis in this thesis is Adam Ockelford’s zygonic theory, which will be discussed in the ensuing chapters.

1.1.1 Research objective 1: melodic expectations for familiar music

The first objective is to empirically investigate the changing interplay between different sources of expectation in the context of melodic repetition in ‘typical’ adult listeners. It is argued that there exists a dynamic interaction between various forms of expectation that stem from current and past musical structures, residing in different memory systems that underpin the music listening experience. The concept of expectation as a vehicle for understanding music was pioneered by Leonard Meyer in his work, *Emotion and Meaning in Music* (Meyer, 1956). In summary, he suggests that musical patterns generate more or less specific expectations about what will ensue, and it is the inhibition or delay of these expectations that gives rise to an emotional response, the strength of which depends on the specificity of the expectation and the nature of the delay. Subsequent work proposes that this continues to happen even when listeners are familiar with pieces. Notably, Ockelford presents a model of musical understanding known as zygonic theory wherein he postulates that the cognition of familiar music is driven by structural relationships between notes that are underpinned by four types of expectation, and typically occur on a non-conscious level (Ockelford, 2006, 2012; Thorpe, Ockelford, & Aksentijevic, 2012). Ockelford's research coordinates with a number of other theories of expectation in music, however there is also some divergence which will be discussed later in this chapter.

The four forms of expectation discussed by Ockelford are as follows. Firstly, *schematic* expectations are relatively inflexible long-term memory (LTM) constructs learned from substantial exposure to music, and offer a general indication of what is to come that can be expressed quantitatively as probabilities (Dowling & Harwood, 1986). They are rapidly activated and, metaphorically speaking, always "hear music as though for the first time" (Jackendoff, 1991). As musical regularities exist at various hierarchical levels, schematic expectations can be generated from as little as two successive pitches (Ockelford, 2006, 2012) that imply several potential outcomes (local processing), to large-scale musical structure (global processing).

Veridical expectations are also learned from prior musical experience and equip listeners with specific knowledge about what will ensue. According to zygonic theory, two forms of veridical expectations exist: the first, *between-pieces* are retrieved from long-term memory and arise between pieces of music as a result of multiple hearings, enabling listeners to have specific expectations about what's coming next, based on an entire piece (Ockelford, 2006, 2012; Ockelford, Trower & Bonneville-Roussy, 2019). The second form of veridical expectations presented by Ockelford are termed *between-groups*, which operate in intermediate-term memory and occur within a single piece (Bharucha, 1987; Ockelford, 2006, 2017; Thorpe et al., 2012) whereby a repeated pattern of notes will generate expectations that rapidly increase in strength as the group of notes unfolds again. A fourth form of expectation also pertains to the current music listening experience, but operates adaptively within groups of notes as they unfold. Current *within-group* expectations are akin to the Gestalt principle of continuity, whereby an unfolding pattern is perceived as more or less predictable, and is based on a perceptual predisposition rather than on previously learned musical structures. Within-group expectations derive from perceived musical patterns or groups that update in real time, decay quickly, and are salient when listening to novel or unfamiliar music. Zygonic theory postulates that within-group expectations yield a range of values since multiple regularities exist simultaneously in the domains of pitch and time, giving rise to several logical continuations (Ockelford, Trower & Bonneville-Roussy, 2019). Broadly speaking, schematic expectations offer a primary source of general implication, current within-group expectations offer a secondary source of general implication, and veridical expectations between pieces and within pieces represent specific continuations (see Table 1.1 for an overview of the four forms of expectation). It is theorised that whilst listening to familiar pieces of music, these various expectancy processes can be activated simultaneously, which enables listeners to anticipate and so savour particular moments (Huron, 2006; Thorpe et al., 2012).

It is important to acknowledge how these definitions differ between researchers. Generally speaking, the terms used by Huron and Ockelford represent those most commonly used. Huron defines veridical expectations as only occurring between pieces of music and not within a piece of music (Huron, 2006), unlike Ockelford's proposition that veridical expectations can occur within and between pieces. Furthermore, Huron coins the term *dynamic* expectations which operate between groups of notes from within a single piece of music, existing in short-term memory. They can arise from a single brief exposure, arising and decaying dynamically as a pattern unfolds and rapidly adapt to the specific piece in real time. Huron's description of dynamic expectations overlaps with Ockelford's between-group veridical expectations and within-group expectations. However, differentially, Huron's dynamic expectations are described as reflecting generalised probabilities that adapt over time as a piece unfolds, whereas Ockelford proposes that between-group veridical expectations are based on specific memories for groups of notes, and within-group expectations pertain to perceptual sensitivity to pattern continuation in response to isolated groups of notes.

Table 1.1 Definitions for different forms of expectation.

Schematic (probabilistic) GENERAL Can occur in novel and familiar music	**Schematic* expectations are relatively inflexible, rapidly activated long-term memory constructs learned from substantial exposure to music, and offer a general indication of what is to come that can be expressed quantitatively as probabilities (Dowling & Harwood, 1986). *They can be generated from as little as two successive pitches (Ockelford, 2006, 2017) that imply several potential outcomes. *They may be low level or high level, where low level processes include pitch adjacency and pitch range, and high level processes include scale degree and phrase boundaries (see page 92).
Veridical (between pieces) SPECIFIC Can only occur in familiar music	**Veridical* expectations are also learned from prior musical experience and equip listeners with specific knowledge about what will ensue. Zygonic theory distinguishes between two forms of veridical expectations. The first, coined *between-pieces* veridical expectations are retrieved from long-term memory and arise between pieces of music as a result of multiple hearings, enabling listeners to have specific expectations about what's coming next, based on an entire piece (Ockelford, 2006, 2017; Ockelford, Trower & Bonneville-Roussy, 2019).
Veridical (between-group) SPECIFIC Can occur in novel and familiar music	*The second form, *between-group* veridical expectations operate in intermediate-term memory, occurring within a single piece (Bharucha, 1987), whereby a repeated pattern of notes will generate expectations that rapidly increase in strength as the group of notes unfolds again (Thorpe et al., 2012).
Within-group (Gestalt) GENERAL Can occur in both novel and familiar music	*A fourth form of expectation also pertains to the current music listening experience, but operates adaptively within groups of notes as they unfold. Current *within-group* expectations are akin to the Gestalt principle of continuity, whereby an unfolding pattern is perceived as more or less predictable. These derive from short-term patterns that update in real time, decay quickly, and are salient when listening to novel or unfamiliar music. *Zygonic theory postulates that within-group expectations typically yield a range of values since multiple regularities usually exist simultaneously in the domains of pitch and perceived time, giving rise to a plurality of logical continuations (Ockelford, Trower & Bonneville-Roussy, 2019).

To understand how expectations evolve in the context of repeated music listening, it is helpful to distinguish between specific and general expectations, and between influences that arise from current musical pieces and pieces heard in the past, each of which might stem from different memory sources and might influence the listener at different rates. For example, melodic predictions that are updated within the working memory system may be influenced by specific memories and general perceptual grouping laws. This is recognised by the zygonic framework, which identifies *specific* between-group veridical expectations occurring within a piece and *general* within-group expectations, whereas the application of Huron's general *dynamic* expectations does not allow the same distinction to be made. Having said that, teasing apart expectations is problematic since melody taps into several domains on multiple hierarchical levels, and thus expectations operate simultaneously. For example, a rising scale that consists of 2-semitone intervals could activate schematic expectations that are based on tonality, as well as within-group expectations based on pattern continuation.

An example of how expectations might operate in a first hearing of a melody helps to clarify the distinction. Imagine a first-time hearing of the vocal melody for the Queen song, *I Want to Break Free* (Deacon, 1983).

- As Freddie Mercury sings the opening phrase "I want to…" (B E F#), the first-time listener might expect the pattern of notes to continue rising. The listener's schematic expectations will suggest that the ensuing notes stay within the tonal context, whereas an implication that the rising pattern will continue may be underpinned by Gestalt-based within-group expectations. Specific veridical expectations will not yet be operative.
- As expected, the vocal melody "…break free" (F# F# G#) continues to rise, however there is a delay during which the F# is repeated. The repetition of the F# may conflict with the listener's within-group expectations, but not with his schematic expectations as the tonal context is not affected.
- As the phrase begins again, "I want to…" B E F#, the first-time listener may expect a repetition of the phrase that was heard previously. Instead, the continuation "…break free" rises to A then falls to G#, thereby disrupting within-

group (pattern continuation) and veridical between-group (pattern repetition) expectations.

- As the listener revisits the song, his within- and between-group expectations may continue to inform predictions, conflicting with his veridical between-pieces expectations about how the vocal melody unfolds.

A second example illustrates how veridical expectations interact with schematic expectations in familiar music. Electronic dance music (EDM) is known for its repetitive structural format involving repeated melodic patterns and 16-bar loops of which *breakdowns*, *build-ups* and *drops* are salient features. Producers of EDM systematically manipulate listeners' schematic and within-group expectations through a) contrasting dynamics and withholding of prominent instrumental and textural elements during breakdowns and build-ups, followed by b) a reintroduction (drop) of the main body of music, often prolonging expectations by adjusting the *when* rather than the *what*. Listeners revel in the veridical knowledge that these moments will occur over and over, resulting in repeated intense emotional experiences (Butler, 2006; Solberg, 2014). Although the concepts of schematic, within-group and veridical expectations are theoretically established, the way in which they interact in response to repeated exposure to familiar music is unclear, thus motivating the current study's first objective.

1.1.2 Research objective 2: development of melodic expectations

The second research objective for the present study is to identify how the interaction between different forms of expectation evolves as a result of typical and atypical development in the context of familiar music. Such investigation should help to understand more fully how expectations operate and therefore how they contribute to melodic perception throughout life. To date, little is known about melodic expectations in children, and even less so about children with autism, even though previous research has indicated that music is particularly important in the lives of children with autism for communication, social interaction and self-expression (Ockelford, 2013). Considering the far-reaching implications of music expectancy research, it is likely that such an endeavour will enhance learning and education in a variety of contexts. Potential stages in the development of musical expectation can be inferred from the *Sounds of Intent in the Early Years* framework (Voyajolu & Ockelford, 2016), which explores the musical development of children from birth to 5 through theoretical and observational study. The *SoI-EY* framework sets out children's musical competencies from the earliest stages to maturation in six 'Levels'. For example, children at Level 3 can make predictions based on pattern continuation (i.e. within-group predictions); those at Level 4 can repeat motifs (employing between-group, veridical expectations), and children at Level 5 can sing entire songs (displaying schematic expectations). These developmental markers of music perception and cognition demonstrate changes in how children make structural connections as they grow older. The current thesis aims to expand on this with quantifiable methods which will highlight trends and tendencies at three time points ranging from early childhood through to late adolescence.

It is recognised that children with autism spectrum condition (ASC) have a particular fondness for repetition in music, and this may be due to differences in memory function compared with their typically developing peers. For instance, it is reported that those with ASC tend to have enhanced local processing: that is, they attune to music on a note-to-note level, finding it easier than typically developing listeners to distinguish between musical events (e.g. single notes) that are perceptually similar (Bouvet, Simard-Meilleur, Paignon, Mottron, & Donnadieu, 2014; Laurent Mottron, Dawson, Soulières, Hubert, & Burack, 2006). Additionally, absolute pitch – an ability to recognise pitches without the assistance of a reference – is relatively common among the autistic population, where individual sounds are described as "familiar friends in a confusing world"

(Ockelford, 2012, p. 136), indicating that pitch is represented differently in the mind. However, the formation of expectations in long-term and short-term memory is still unclear.

Accordingly, it is hoped the second objective of this study will facilitate a deeper understanding of how melodic expectations evolve in typical and atypical development in the context of familiar music, which may indicate how various forms of expectation operate within different memory systems, which can inform therapy, pedagogical practice, and discussion about the development of pleasure through music listening.

1.1.3 Thesis and chapter outline

Chapter 2 introduces the primary methods employed in musical expectancy research, presenting their strengths and limitations and a rationale for the methods used in the present study. Participant recruitment, methodological design, procedure, and ethics are also discussed. Chapters 3-6 report the main body of the research. Chapter 3 reports the study on typical adults, chapter 4 examines typically developing children, chapter 5 presents the results from children with ASC, and chapter 6 integrates all participant groups. Chapter 7 presents the discussion, and the conclusion is presented in chapter 8.

This chapter introduces the theoretical and empirical foundations that motivate this thesis. Section 1.2 begins with the theoretical underpinnings of musical expectancy research, notably the pioneering work of Meyer, followed by more recent theoretical and empirical research on musical expectation in section 1.3. Thereafter in section 1.4 three cognitive models of musical understanding are introduced, each of which are grounded in expectation. Next, melodic expectations of typically developing children are considered in the context of perception, cognition, and memory in section 1.5. Section 1.6 reviews models of perception in autism, and empirical research on memory and learning. Finally, in section 1.7, the research questions and hypotheses for this thesis are presented.

1.2 Expectation in music – theory: Leonard Meyer's *Emotion and Meaning in Music*

Meyer's seminal book, *Emotion and Meaning in Music* (1956) forms the ultimate inspiration for the present research (and much of the research in this literature review). He draws on three existing theories – John Dewey's conflict theory of emotions (Dewey, 1894), Claude Shannon's information theory in the context of statistical learning (Shannon, 1948), and aspects of Gestalt psychology (Koffka, 1935) – to explain how music conveys meaning and emotion through the way that it is structured. Meyer begins by discussing the epistemological approaches that pertain to music and meaning, differentiating between two key schools of thought: *absolutists*, who contend that musical meaning stems from the stuff itself, and *referentialists* who posit that meaning can be engendered from extra-musical associations. He goes further, to distinguish between two central aesthetic approaches: the *formalist* position, which holds that musical understanding is intellectual and devoid of emotional sensation, and the *expressionist* viewpoint, that feelings and emotions do indeed arise from music. Meyer states his position as an absolutist, and argues that both formalist and expressionist schools of thought can inform understanding how structured sound can become musically meaningful (formalist) and emotionally stimulating (expressionist). Having established the theoretical approach, Meyer presents his theory of musical expectation as a vehicle for producing music-induced meaning and affect.[1] In the following sections, I aim to demonstrate how Meyer's theory can bolster new theoretical and

[1] The current review uses the terms emotional response and affective response interchangeably, adopting Meyer's definition of affect or emotion as an evanescent '*feeling-tone*' of the emotional experience as music develops over time and as different from a stable emotional state which tends to be in response to constant musical features like tempo (Meyer, 1956).

empirical inquiry into how melodic expectations develop during repeated listening to music.

1.2.1 Conflict theory of emotions

The first component of Meyer's theory of musical expectation is based on John Dewey's conflict theory of emotions (Dewey, 1894) and is understood to be the basis for emotional responses to music through which elements from information theory and Gestalt psychology are interwoven. Dewey's original theory proposes that the disruption of a regular behaviour or thought process leads to an emotional response. Relating this to music, Meyer states his central thesis that 'emotion or affect is aroused when a tendency to respond is arrested or inhibited' (Meyer, 1956, p. 14). In other words, tension is generated when a musical event or process conflicts with listeners' expectations about what is to come, and an emotional response is felt upon hearing a resolution. A greater build-up of tension produces a more powerful emotional response. Despite often referring to musical tension, Meyer suggests that responses to music are likely to be positive as a result of learning that moments of suspense tend to be followed by a resolution.

1.2.2 Statistical learning and information theory

In order to demonstrate whence expectations arise, Meyer proposes that meaning is derived from multi-layered structures of context-dependent probability relationships pertaining to features such as tonality, form, rhythm, and other hierarchical and temporal factors (Meyer, 1956). Probability relationships are learned non-consciously via exposure from childhood and can be thought of in abstract terms as long-term memory frameworks, now commonly known as schemas. Huron defines the schema as "an encapsulated behavioural or perceptual model that pertains to some situation or context" which prepares an organism to act rapidly based on the most probable outcome (Huron, 2006). In musical-auditory terms, different musical styles or genres will activate different sets of schemas upon which listeners' expectations are formed. Meyer explains the nature of probability relationships in music by drawing on two key aspects of information theory (Shannon, 1948). Information theory is concerned with the content and communication of messages by measuring the amount of new information, otherwise known as entropy. The more 'bits' of information that are present in a message, the weaker the predictability; while, conversely, a message or outcome that is 100% predictable will contain zero bits of information (Huron, 2006, p. 114). For example, the flip of a coin that has heads on both sides is entirely predictable, and therefore has no entropy as it does not contain any new information. Of additional significance is the concept of 'Markov chains', which are based on conditional probability, whereby the probability of an outcome is based on prior context. For instance, in music the probability of the tonic occurring is more likely when preceded by a leading tone (Benward & Saker, 2008). Based on these concepts, Meyer draws a parallel between the predictability of a musical process and its potential affective power, suggesting that the greater the spread of probability in a musical passage or event, the more ambiguous the expected outcome, and the less potential there is for an expectancy violation to have an emotional impact.

1.2.3 Gestalt psychology

A third component of Meyer's theory is based on Gestalt psychology, a branch of psychology that was originally associated with visual perception. Meyer stresses that although musical meaning is mutable over time as a result of fluxes in perceived probabilities, the way in which meaning arises in the mind of the listener is consistent, in that there is an unremitting tendency to look for completeness and simplicity (Koffka, 1935). He utilises a key Gestalt principle known as the *Law of Prägnanz*: that the mind "tends to complete what was incomplete, to regularise what was irregular" (Meyer, 1956, p. 89). Essentially, the Law of Prägnanz describes how we naturally interpret complex images in the simplest way possible. In musical terms, the better the psychological organisation, the less likely an emotional response will be aroused; and the better the psychological organisation prior to disorder, the stronger the resulting affective feeling. Based on this, Meyer presents Gestalt-based principles that can influence affective responses to music, most notably:

a) The Law of Good Continuation: A shape or pattern will be continued in its initial mode of operation, and a violation of a musical progression will conflict with expectation. This could appear in the form of temporary halts or changes in process.
b) Completion and Closure: This is based on the idea that we have a tendency to seek perceptual completeness. Meyer uses the example of a structural gap such as a note missing from a perceived triadic movement. A sense of yearning for the gap to be filled will result in emotional affect upon its eventual realisation.
c) The Weakening of Shape: A sense of order or ‘good’ shape is important for generating a sense of progression; however, a weak or ambiguous shape is also important for aesthetic reasons because it can arouse a strong desire for musical clarity.

1.3 Expectation in music – theory: aesthetic responses to music

A simple example (Figures 1.1 and 1.2) can show how the conflict theory of emotions, information theory, and Gestalt-based concepts can generate an aesthetic response by departing from an established pattern within the context of Western music, during a first listen. In the key of C minor, the opening melodic phrase of *My Funny Valentine* (Rodgers & Hart, 1937) in bars 1 and 2 is repeated in bars 3 and 4, establishing a pattern with a tonal centre of C minor.

Figure 1.1. Piano and vocal score for bars 1-6 of *My Funny Valentine* (Rodgers & Hart, 1937).

A melodic and rhythmic deviation occurs at the start of bar 6 (Figure 1.1.), mid-way through what appears to be a third repetition of the phrase. Rather than the expected continuation of the phrase already in motion, the melody ascends a perfect 5^{th} to B flat, lingering for an extra half-beat before descending stepwise and completing the phrase on F, as seen in Figure 1.2.

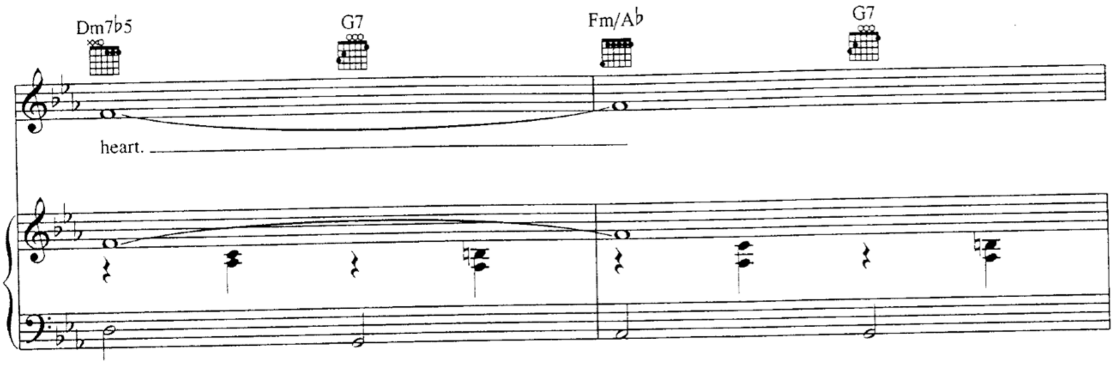


Figure 1.2. Piano and vocal score for bars 7-8 of *My Funny Valentine* (Rodgers & Hart, 1937).

In the context of Meyer's theory of expectation (1956), an emotional response is caused here by a conflict between expectation and realisation. Specifically, the B flat in bar 6 thwarts expectations in two ways: firstly, by deviating from the expectation that the phrase will be imitated, and secondly, due to the leap from the median to flattened leading note (in the context of chord IV), causing dissonance. The tension created by the B flat is reduced when the melodic line partially resolves to the F. The phrase eventually comes to a close, resting on chord V in the final two beats of bar 8: the dominant harmony, in the context of Western tonality, implying that there is more to come.

This example demonstrates how melodic expectations and realisations might influence a listener's expectations on a first hearing. However, what happens when the listener has heard the piece for a second time? It is known that simple 'liking' of a stimulus can increase with familiarity, even as a result of non-conscious exposure (Russell, 1986; Zajonc, 1968), and this can lead to the experience of savouring anticipated moments in music (Ockelford & Grundy, 2014). The knowledge that unexpectedness leads to a desired aesthetic response that can be achieved by the same stimulus more than once provokes the question: if the disruption of expectations causes an emotional response, how can elements of music continue to be unexpected (and thus arouse emotion) even when the listener knows what is coming next?[2] Meyer proposes that musical repetition doesn't exist psychologically, only physically (1956 p.49), and that the listener engages a "willing suspension of disbelief" (Meyer, 2001 p.352). Of a similar vein, Ray Jackendoff proposes an innate 'music module' in the brain that always hears familiar pieces as though for the

[2] Ruth Grundy and Adam Ockelford (2014) note that this paradox dates back to 1815, quoting Thomas Love Peacock's Headlong Hall, about experiencing the unexpected for a second time: *"Allow me," said Mr Gall. "I distinguish the picturesque and the beautiful, and I add to them, in the laying out of grounds, a third and distinct character, which I call unexpectedness." "Pray, sir," said Mr Milestone, "by what name do you distinguish this character, when a person walks round the grounds for the second time?"*

first time, enabling listeners to remain engaged with pieces even having heard them several times (Jackendoff, 1991). A more credible solution focuses on learning, and resides in the interplay between the conscious and subconscious, wherein the mind's natural propensity to prepare for the future facilitates quick and automatic (schematic) expectations that are unaffected by conscious recognition, which operate in conjunction with specific (veridical) expectations about what is to come (Dowling & Harwood, 1986; Bharucha, 1987). The 'deceptive cadence' is a common example: even in the veridical knowledge that the submediant will follow the dominant (V–vi), the schematic expectation for the tonic to follow (V–I) – based on regularities in Western classical music – will consistently 'deceive' the Western-encultured listener. This conjecture also accords with widely reported psychological research on 'dual processing' (Kahneman, 2011), which in general terms posits that processes in 'System 1' are rapid and automatic, essentially yielding default responses, while 'System 2' processes are conscious, slow and deliberate (Evans & Stanovich, 2013).

As touched upon in the introduction, a significant contribution to the discussion of pleasurable responses to music is Huron's ITPRA theory of expectation (Huron, 2006). He offers an evolutionary framework of how and why listeners are predisposed to anticipate future occurrences based on experience, proposing a sequence of anticipatory and reflexive responses that occur prior to and after a musical event. First, a principal mechanism for behavioural motivation is termed the *imagination response*, which describes the desire to seek a prospective pleasurable emotion connected to an upcoming musical event. A *tension response* quickly follows, which involves rapid physiological and perceptual preparation for an expected event, typically resulting in increased heart rate and blood pressure. Uncertainty about the 'what' and 'when' impacts the strength of arousal. After an event occurs, a *prediction response* rewards correct predictions with positive feelings, and incorrect predictions with negative feelings. Even when an expected outcome is 'bad', accurate predictions are still rewarded positively. The final two responses are related to the pleasantness of the outcome itself. A r*eaction response* is driven by learned schemas, deep-seated in memory, and is rapid and reflexive. An *appraisal response* involves a conscious evaluation of the outcome which may or may not reinforce the reaction response. He explains why a conflict between musical expectation and realisation can generate a pleasurable response in the listener, whereby positive feelings resulting from a successful prediction are misattributed to the stimulus. Moreover, the concept of contrastive valence can explain why surprising events can still be positive. This occurs when an expectation is thwarted, but the outcome is still positive, such as when a football player doesn't expect to score, but in fact he does, whereby the negative effect caused by the surprise then amplifies the positive effect of the outcome.

Of particular relevance is Huron's connection between types of expectation and memory. Although not exactly identical, there are similarities between the current definitions and those proposed by Huron. He proposes that schematic expectations are grounded in semantic long-term memory which holds factual knowledge that is accumulated throughout life and which is not subjectively tied to past experience, yet still encompasses *noetic consciousness* – a familiarity of knowing (Martin-Ordas, Atance, & Caza, 2014). He further writes that veridical expectations stem from episodic long-term memory which stores specific information about past events, describes the capacity for mental time travel of past and future events (Tulving, 2005), and is compartmentalised into the what, when and where. Episodic memory is indicated as a*utonoetic consciousness* – a first-person phenomenological awareness based on previous experiences that belong to an individual (Martin-Ordas et al., 2014; Tulving, 2005). These definitions are still unclear, however, as veridical expectations are not necessarily noetic, since listeners can know a piece or musical event without remembering from when or where. Huron adds that *dynamic* expectations occurring in short-term memory can arise and decay due to repeating patterns heard within a piece of music as it unfolds (Huron, 2006). Such postulations about memory and expectation will be addressed in the discussion section of this thesis, which will help to inform theoretical and empirical investigation of musical expectation, musical memory, and the cognitive modelling of musical understanding.

Considering that music contains extraordinary amounts of repetition occurring on both a temporal and hierarchical level and which traverses various perceptual and cognitive domains, the need for a multidimensional approach has resulted in several predictive models of musical understanding which acknowledge the salience of pattern detection through schematic learning and perceptual organisation (for example Margulis, 2005; Narmour, 1990, 1992; Ockelford, 2006, 2012; Pearce & Wiggins, 2006, 2012). Such models are vital to the field of music cognition as they observe and simulate moment-by-moment fluctuations supported by behavioural findings and musical examples. Strands from Meyer's initial theory (1956) remain present in the subsequent models, as discussed below.

1.4 Modelling expectations

1.4.1 The implication-realization model

Narmour's implication-realization (IR) model, often regarded as the first significant model of its kind, takes a combined cognitive and musicological approach, utilising core components from Meyer's theory and formulating a predictive framework to explain how melodic structures are understood (Narmour, 1990, 1992). At the heart of Narmour's model is the proposition that two expectation systems are vital for the perception and cognition of music through which musical input is processed and implications about future musical events are generated. The first, top-down, system comprises schematically learned bundles of stylistic features that are procedurally dependent and consciously accessible, and include memory for specific works and composers, whereas the second, bottom-up, system is formulated from innate 'pattern detecting' cognitive universals that remain rigid and automatic, rooted in the subconscious. Extending Meyer's thinking and echoing the conjectures of Dowling and Harwood (1986) and Bharucha (1987), Narmour suggests that melodic aesthetic affect is not only a product of the violation of listeners' expectations, but also a result of conflicting implication between two expectation systems – the conscious and subconscious (Narmour, 1990, pp.35-42). This may explain why, seemingly, patterns in familiar pieces remain surprising to the listener because the subconscious always responds to music as though it were novel (1990, p.40).

Gestalt-based perceptual organisation – a core feature of Meyer's work – is presented in the IR model's bottom-up system. Five central principles of music cognition are proposed (Narmour, 1990, 1992; Krumhansl, 1995a), namely:

a) Registral direction: small intervals imply continued pitch direction, and large intervals imply a change in direction,
b) Intervallic difference: small intervals imply similar sized intervals, and large intervals imply small intervals,
c) Registral return: a symmetrical or near-symmetrical melodic archetype concerning melodic direction e.g. ABA,
d) Proximity: small intervals are more commonly implied than large intervals; and
e) Closure: melodies are segmented according to two options – a larger implied interval is followed by a smaller realised interval, or a realised interval that is in a different direction to what was implied.

The above 'universal constants' are suggested by Narmour to communicate with long-term memory schemas learned from prior musical experience. Such schemas are part of the top-down system, which is divided into *intraopus style* – influences from within a piece – and *extraopus style* – influences from other pieces. Narmour concurs with Meyer that style is a product of learned mental representations of repeated musical experiences, which might be specific or non-specific. Each of these generalised ‘laws’ are described in terms of interval size and direction, and this is critical for the model’s applicability as it allows quantitative and therefore testable predictions to be made.

Empirical studies motivated by the IR model consistently agree that pitch proximity is a pertinent feature of music perception, whereas support for the remaining principles is varied. For example, Carol Krumhansl (1995a) conducted three experiments in which listeners were presented with melodic fragments that ended halfway through a phrase, after which a continuation tone was heard. This was repeated until each continuation tone was played. The final implicative intervals at the end of each fragment (including the continuation tone) represented small and large intervals in ascending and descending directions. Listeners were required to make judgements about how well the continuation tone met their expectations about what might follow, using a rating scale ranging from 1 (extremely bad continuation) to 7 (extremely good continuation). In the first experiment, the musical fragments were taken from British folk songs whereby the continuation tones were diatonic scale tones. Ten listeners were musically trained, and the remaining ten had no formal musical training. In the second experiment, atonal music was presented to thirteen musically trained and thirteen untrained listeners. Eight native Chinese and eight native Americans were presented with Chinese folk songs in experiment 3. Statistically significant correlations between the IR model’s five principles of organisation and the listeners’ ratings show that all five principles could predict the expectations of listeners across all three musical styles and for all nationalities and musical backgrounds. Pitch proximity was the strongest predictor. In a separate study, Krumhansl (1995b) presented Western-encultured adult listeners with two-tone intervals ranging from a descending major 7^{th} to an ascending major 7^{th}. Listeners were required to make continuation judgements about how well the third tone met their expectations about what might follow each interval. Support was found for proximity, registral return, and registral direction, although the IR model's exact parameters were modified. Support is also reported by Cuddy and Lunney (1995), who had 24 adult musicians and non-musicians from a Western musical background rate how well a third tone continued a large or small interval posing as a melodic beginning. Again, proximity was the strongest predictor, followed by intervallic difference, registral return, and a modified version of registral direction. They also report that tonality is an influential predictor, both in terms of specific and multiple implications of key.

Glenn Schellenberg's subsequent tests of the model (Schellenberg, 1996, 1997) suggest that adjusted versions of pitch proximity and pitch-reversal alone may hold sufficient predictive power for modelling expectancy in melody. Narmour's original quantification of pitch proximity states that all large intervals are equally non-proximate, whereas Schellenberg quantifies the principle linearly with incremental measurements according to interval size (Schellenberg, 1997). The pitch-reversal principle is a combination of Narmour's original principles of registral return, intervallic difference and registral direction and describes the expectation that a tone will not only be proximate to the one that preceded it but also to the one prior to that. Specifically, the pitch-reversal principle describes expectations for when large implicative intervals are heard (i.e. non-contiguous pitches) and suggests that listeners expect a change in direction and a small interval. However, results from corresponding studies are mixed depending on the musical context. For example, Krumhansl, Louhivuori, Toiviainen, Järvinen, & Eerola (1999) asked Western and Finnish listeners to make melodic expectation judgements in response to Finnish spiritual folk hymns, and found no support for Schellenberg's two-factor model (1996, 1997) compared with three other versions of the IR model, although the linear version of proximity was the strongest predictor for all four models, as was tonality. Schellenberg et al. (2002) found the two-factor model to be the most effective predictor compared with the IR model when judging melodic expectations in a Western music context. Interestingly, Krumhansl et al. (1999) reported that the functioning of the principles found to be significant were not dependent on familiarity with the music, which is consistent with Narmour's conjecture that universal bottom-up 'laws' are processed independently from top-down musical knowledge. However, it is also suggested by the experimental studies reported above (Cuddy & Lunney, 1995; Krumhansl et al., 1999) that tonality should feature in cognitive models as a factor that functions alongside bottom-up perceptual principles.

Some alternative approaches to modelling expectations have since developed, which address various aspects of music perception to varying degrees (Eerola, Himberg, Toiviainen, & Louhivuori, 2006; Farbood, 2012; Lerdahl, 2001; Lerdahl & Krumhansl, 2007). Of note is Elizabeth Margulis's model of melodic expectation (Margulis, 2005) which is built on the core concepts of *proximity*, *tonal stability*, and *direction*, drawing on Gestalt-influenced ideas introduced by Meyer (1956), factors pertaining to intervals and direction as discussed by Narmour (1990, 1992), tonality as exampled in some empirical studies (Cuddy & Lunney, 1995; Krumhansl et al., 1999), and the introduction of new concepts such as tension and mobility. Margulis's model is noteworthy because of its inclusion of tonality as a primary factor and the dynamic approach not seen in the IR model, although the bottom-up only rating system does not consider the influence of repetition on expectations. Although pitch repetition is incorporated into the model (the expectancy that A will be followed by A), the repetition of phrases or groups of notes both within pieces and between pieces are excluded from discussion. Different forms of repetition will suggest to the listener that a musical pattern may occur again in some way, and so it is important that these are recognised when modelling listener's expectations.

Alternatively, models based on statistical learning take the approach that music perception and cognition can be understood as stemming from probabilistic processing based on learned regularities that occur within a particular musical context, rather than on static perceptual laws of melodic organisation such as those presented by Narmour and Margulis. It is argued that this approach is more realistic of human cognition, since it represents dynamic, mutable expectations and can thus facilitate investigation into enduring emotional responses to familiar music, as well as developmental changes. For example, Rohrmeier and Rebushcat (2012) review evidence to support the argument that implicit learning drives music cognition and is involved in the formation of schemas, including those for tonality, harmony, timbre and rhythm. That is not to say that intentional learning does not contribute additionally to one's musical understanding (e.g. James, Dupuis-Lozeron, & Hauert, 2012; Kuhn & Dienes, 2006). Two significant models that incorporate the statistical learning approach are zygonic theory and the zygonic model (Ockelford, 2006, 2012; Thorpe et al., 2012) and the Information Dynamics of Music (IDyOM) model (Pearce, 2018; Pearce & Wiggins, 2012) which are reviewed below.

1.4.2 The zygonic model of expectation

As a natural successor to the models that precede it, the zygonic model of expectation combines music theory and analysis with cognitive psychology and aims to model music-structural cognition in a way that is both dynamically intuitive and empirically testable. The central focus of zygonic theory is the notion that music cognition stems from the sense that structural musical features are perceived to exist in imitation of one another (Ockelford, 2006, 2012), generating expectations that pervade all aspects of music perception. Extending Meyer's original notion that the violation of expectations is a precursor for emotional affect, Ockelford proposes that the *anticipation* of upcoming events is a powerful source of emotional pleasure, as also noted by Huron (2006).

Zygonic theory is supported with diagrams in which symbols are superimposed onto musical excerpts (using standard Western musical notation) and utilises statistical analyses of case studies and musical examples. The theory holds that meaning stems from ‘interperspective’ relationships that bridge the mental gap between musical events (referred to as *perspects* – which could refer to pitch, onset, or some other musical value), which create a sense of order in music. Interperspective relationships can exist on different levels, where *primary* relationships link isolated musical events (or *perspective values*), *secondary* relationships connect primary relationships, and *tertiary* relationships connect secondary relationships. Interperspective relationships are also assigned values pertaining to polarity and magnitude. If interperspective relationships linked through a sense of derivation i.e. they are perceived to be related to one another, they are deemed as zygonic. Hence, zygonic relationships are underpinned by expectations which can operate *reactively* or *proactively*. The zygonic model proposes that expectations arise from:

a) previously heard musical structures encoded *schematically* that offer a general sense of what is to come based on past trends and tendencies;
b) *current within-group* musical structures that offer a secondary source of general implication, e.g. pattern continuation, and
c) previously heard musical structures encoded *veridically*, providing specific knowledge about what is to come. It is posited that the relationship between these three sources of expectation changes over the course of listening to a piece for the first time and in subsequent hearings.

In terms of the model’s functionality, statistical learning plays an important role, in that schematic projections create relationships within and between groups of notes, occurring in short-term and long-term memory. It is suggested that these projections are based on probabilities from varying domains such as pitch degree, harmonic transitions, and perceived time (Ockelford, 2006, 2012; Thorpe et al., 2012). Specifically, zygonic model Z3 incorporates the following principles, each of which offer a probability distribution for each pitch as the music unfolds:

a) *adjacency* whereby the strength of expectation is based on the proximity of the note that precedes it,
b) *recency* which holds that the strength of expectation for a particular note is also influenced by temporal proximity, which is modelled as far back as four events, each of which increases in strength the closer it is to the expected continuation; and
c) *between-groups* whereby a repeated pattern of notes will generate expectations that rapidly increase in strength as the group of notes unfolds again.

Experimental tests of the zygonic model show that it can predict expectations for a first hearing in the context of Western music (Ockelford & Grundy, 2014; Thorpe et al., 2012) and atonal music (Ockelford & Sergeant, 2013). Notably, Thorpe et al., (2012) examined sung continuations of forty adults who had been presented with a 26 note diatonic melody, and compared the mean responses with zygonic model Z3, accurately simulating expectations for a first hearing in the context of Western music, supporting the theory that expectations are generated schematically both within and between groups of notes.

Ockelford stresses that the experience of multiple hearings should also be integrated into models of musical expectancy, in addition to predicting what listeners expect to hear when listening to a piece for the first time. Accordingly, a pilot study reported by Trower (2011) indicates how various expectations might interact in response to melodic repetition. Seven adult participants rated their perceived expectedness in response to sixteen pairs of melodic fragments in a major scale separated by a short unmelodic distractor. Each pair consisted of two identical fragments. The second melodic fragment in each pair was consistently more expected than the first, but interestingly, the pattern of expectation persisted, in that the direction of expectedness for each interval was not affected by the repetition. The results reveal the presence of two expectational forces and implying that further repetitions would generate intact schematic expectations alongside an increase in the dominance of veridical expectations. Margulis' (2014) adaptation of Cone's 3-stage analysis of repeated listening (Cone 1977) proposes a similar outcome, whereby the first stage represents the first hearing of a piece during which the surface features of a piece are absorbed, followed by a second stage and a continuation of familiarisation. By the third stage, listeners are fully acquainted with a piece and can immerse themselves in the music without the need to process any further information. Correspondingly, Wong and Margulis (2008) report that intense engagement with a piece is negatively correlated with familiarity, meaning that peak musical events are felt more intensely when familiarity increases. This accords with Ockelford's conjecture that with each repeated hearing of a piece, general projections will diminish, and specific expectations will dominate. Despite the preliminary support reported here, more investigation is necessary to be able to understand the changes that occur in response to repeated exposure to musical pieces.

1.4.3 The Information Dynamics Of Music (IDyOM)

The zygonic model of expectation in music bridges the gap between musicological and psychological modelling of music, whereas IDyOM is computational in its approach, proposing that music cognition is underpinned by general-purpose learning mechanisms rather than representational rules as conjectured by Narmour (1990, 1992). Furthermore, IDyOM proposes that probabilistic prediction preceded by statistical learning is a fundamental perceptual process for all domains including music (Pearce, 2018; Pearce & Wiggins, 2012). Also influenced by the work of Meyer (1956), IDyOM is grounded in information theory, where the level of expectedness in a particular musical event is measured by its information content. The higher the information content, the more uncertainty is associated with that event. As supported by behavioural evidence, it is argued that the model can simulate various psychological processes that relate to music perception through the measurement of information content, such as emotional experience whereby higher subjective and physiological arousal is linked to passages with higher information content (Egermann, Pearce, Wiggins, & McAdams, 2013), recognition memory whereby more complex passages that have higher information content are more difficult to retain in memory, and phrase-boundary perception whereby grouping boundaries tend to occur before unpredictable events that have a high information content (Pearce, 2018).

The model learns the statistical regularities of music via the combination of two sub-models labelled LTM and STM which loosely represent Bharucha's (1987) definition of veridical and schematic expectations. The long-term model is exposed to a large corpus of music which simulates listeners' long-term memory processes, and the short-term model is only exposed to the current piece, simulating short-term current listening. Each model generates pitch-by-pitch probability distributions which are then combined to give a single distribution for each note in a melody (Pearce & Wiggins, 2012). Importantly, IDyOM recognises that listeners' expectations are dependent on long-term knowledge of a musical style, as represented by the LTM model; but crucially, it also recognises through the STM model that listeners alter their expectations in response to repeated structure within a piece of music. IDyOM also derives distributions (or models) from surface features of pitch data relating to frequency and time, including note onset, pitch as identified by a MIDI number, pitch duration, onset, attributes derived from onset, and derived values that identify tonal and melodic structure, as well as tonal and rhythmic structure (Pearce, 2018). These values are combined to generate a probability distribution for each pitch within the STM and LTM models prior to generating a final distribution value for each pitch in a melody. In terms of accuracy of prediction of human music cognition, it is reported that IDyOM generates the most accurate predictions of melodic expectation when compared with Narmour's IR model (Pearce & Wiggins, 2012).

Music perception and cognition is inherently dynamic, and thus IDyOM is more representative of music perception compared with the more static rule-based models proposed by Narmour (1990) and Margulis (2005). Of interest to the current thesis is IDyOM's support for statistical learning within a musical structure or piece. Again, this is an advantage over the models proposed by Narmour and Margulis. However, in terms of predicting how expectations alter in response to hearing the same piece multiple times, it is assumed that the lack of speculation as to how this might be approached using IDyOM is because there is currently very little behavioural evidence upon which IDyOM can generate theoretical assumptions with which to compare its output; a query to be addressed in the current thesis. On the other hand, the zygonic model is grounded in an established theory which provides the foundation upon which to explore such phenomena, whilst still utilising the concept of probabilistic learning.

1.4.4 Modelling expectations: summary

The above reviewed cognitive and theoretical models of expectation have been selected in this literature review because they all draw on the seminal work of Meyer (1956), yet they illuminate some key changes in music expectancy research over time. To begin, Narmour's IR model provides a platform upon which the core elements of Meyer's theory can be quantified according to interval size and direction. Narmour postulates that the essence of musical understanding may stem from the simultaneous activation of two expectation systems: firstly, the universal bottom-up pattern detecting principles and secondly, the style-specific feature analysing processes. Margulis develops the work of Narmour (1990, 1992), and Lerdahl (2001), bridging the gap between symbol-heavy modelling and the temporal listening experience by developing a rating system that represents fluctuations in reactive and proactive listening. Significantly, expectations based on tonality are regarded as deeply ingrained, reflecting a change in belief about what is viewed as schematic; differing, for example, from Narmour's position that automatic bottom-up processing pertains only to innate laws of perceptual organisation. Pearce and Wiggins (Pearce, 2018; Pearce & Wiggins, 2006, 2012) emphasise a preference for dynamic statistical learning over static rule-based modelling of musical understanding, disregarding the conjecture that music cognition is driven by representational or symbolic mental processes. Zygonic theory, described as psychomusicological, combines aspects from supporting empirical studies with musicological knowledge to simulate the statistical learning of patterns occurring within and between pieces of music, based on current and past structures. Notably, zygonic theory offers a theoretical and empirical framework upon which repeated listening to music can be investigated.

1.5 Melodic expectations in typically developing children

The literature reviewed thus far pertains to the expectations of adults with no intellectual disability. A more comprehensive understanding of the origins of expectations can be gleaned from examining them from a developmental perspective, including children ranging from early childhood through to adolescence, and those who are on the autistic spectrum. The second half of this literature review pertains to two groups of children, whose musical expectations have been little studied, namely typically developing children and children with high-functioning autism.

1.5.1 Music development: expectations

The perception and cognition of music in general has received considerable attention (for example, see McPherson, 2015; Hargreaves & Lamont, 2017), but the development of musical expectations remains an area yet to be explored. This is surprising, considering the significance of expectation for musical understanding and the potential that this area of study has for the study of perception and cognition in general. Prior to the current thesis, only a few studies focus directly on musical expectations in children.

The first of these was conducted by Schellenberg, Adachi, Purdy, and McKinnon (2002), and focuses on perceptual principles by comparing children's expectancy ratings with Narmour's IR model (1990, 1992) and Schellenberg's 2-factor model (Schellenberg, 1996). In the first of two experiments, children aged 7-8, children aged 10-11 and adults rated how well a tone continued a novel melodic fragment. Four fragments, 15 notes in length, were extracted from French-Canadian folk songs and ended halfway through a phrase to imply continuation. Two fragments ended in a small upward implicative interval (2 or 3 semitones), and the other two ended in a large upward implicative interval (9 or 10 semitones). Adults and older children made ratings by clicking a scale on a computer screen ranging from 1 (extremely poor continuation) to 7 (extremely good continuation), and younger children clicked a pictorial scale where each point matched with a drawing of a face on a computer screen ranging from 1 (very sad) to 5 (very happy). Adults and older children provided a total of 60 ratings, and younger children provided 30 ratings. During the second experiment, 45 children (5-, 8-, and 11-year olds) sang continuations to 50 melodic intervals (25 intervals each at two octaves). Results from experiment 1 show that during the first experiment an expectation for pitches to be proximate was evident in children as young as 7-8 years old, and the effect of that principle grew in strength for children aged 10-11 and further strengthened for adults. There was no difference in the predictive accuracy of pitch proximity between adults and older children, and the authors suggested that pitch proximity reaches an adult level of accuracy somewhere between 8-11 years of age. The more complex process of pitch reversal, which is the expectation for a large leap (seven semitones or more) to be followed by a change in melodic direction and considers three pitches, was absent in children (although it did increase in strength as children got older) but was present in adults. Results from experiment 2 indicate that pitch proximity was equally effective for all ages. On the other hand, pitch reversal followed an extended developmental trajectory wherein it was a better predictor for 11-year-olds compared with 5-year-olds, and also for 8-year-olds compared with 5-year-olds.

Jentschke, Koelsch, & Friederici (2005) examined expectations in typically developing children from a different methodological and theoretical perspective. Their aim to was explore the relationship between music and language using electroencephalogram (EEG) data based on the hypothesis that music and language syntax share the same neural resources known as ERPs (event-related potentials). Specifically, an ERP known as the ERAN (early right anterior negativity) is triggered by music-syntactic violations, and the ELAN (early left anterior negativity) is triggered by language-syntax violations. Twenty-eight 11-year-olds with and without musical training and 24 5-year-olds with and without a language impairment took part in a music and language experiment. Children were presented with 5-chord sequences ending on a tonic (musically related) or supertonic (musically unrelated), followed by sentences containing a violation of structure or a predictable structure. During each experiment, participants were instructed to detect changes in timbre. Results revealed that children in both age groups were sensitive to the tonal violations, demonstrating schematic knowledge of Western tonal and harmonic structure, and that this was more pronounced in musically trained children. The findings were also similar for language syntax violations whereby the typically developing children from both age groups exhibited sensitivities to violations and the finding was more pronounced in children with musical training, suggesting that the detection of regularities in language and music are both facilitated by music training. The 5-year-olds with a language impairment did not show any such sensitivities. Overall the findings show that children as young as five years implicitly learn structural musical and language regularities and that this is enhanced with musical training.

James, Dupuis-Lozeron and Hauert (2012) found similar results. They assessed detection of musical syntax violations in monophonic and polyphonic novel stimuli in 112 children aged 6-11. The syntax violation occurred at the end of the stimuli, and was either a) congruous, b) subtly incongruous and in-key, or c) markedly incongruous and out-of-key. Children judged goodness of fit by marking a line across a vertical bar with a happy face at the top and a sad face at the bottom. Their results showed that children of all ages rated the stimulus endings in order of congruence, and that the congruous and markedly incongruous ratings become more extreme with age, indicating that young children implicitly absorb musical syntax, and that this increases with mere exposure as a result of age, although this may also be linked to cognitive development such as memory improvement and efficiency, and improved expertise in other domains such as language learning as discussed by Schellenberg et al., (2002). Moreover, musical training led children to perceive subtle incongruity and marked incongruity as less fitting, and congruous endings as more fitting, but the overall trends were the same as non-trained children. Interestingly only musical training and not age generated better detection of subtle syntax violations.

Taken together the above studies are significant in understanding the development of expectations, as they demonstrate that children exhibit schema-driven expectations about the narrative of a melody, and that this occurs from early childhood, becoming more complex as they grow older, and that explicit learning through musical training can enhance such developmental progression. This relates to an observational study conducted by Voyajolu and Ockelford (2016), whose findings can be explained in terms of expectations. They report that children's age may correlate with increasingly complex 'Levels' of musical engagement according to a specific framework. They observed 58 children aged between ten weeks and four years, over a six-month period, for two hours per week, totalling 125 observations of children engaging in musical activity. The observations were applied to the *Sounds of Intent* (*SoI*) framework, originally created from hundreds of observations of children with mild to severe disabilities. The original *SoI* framework conceptualises musical engagement as occurring within three domains: *reactive* (responses to sound and music), *proactive* (the creation of sound and music), and *interactive* (interaction with others through sound and music). Within each domain are six ability 'Levels', ranging from Level 1 whereby there is no evidence of awareness of sound or music, to Level 6 which describes mature musicianship. Voyajolu and Ockelford found from observations of typically developing children that musical engagement could be related to *SoI* Levels 2 to 5 within the three domains of reactivity, proactivity and interactivity. Their findings relate to the expectancy processes set out in Ockelford's zygonic model (Thorpe et al., 2012). For instance, according to the *SoI* framework, a child who engages with music at Level 3 can 'intentionally make patterns in sound through repetition or regularity' in the proactive domain (Voyajolu & Ockelford, 2016). The creation of repetitive patterns of sound demonstrates an ability for pattern continuation, or within-group predictions. A child who engages at Level 4 'creates or recreates short groups of musical sounds and links them coherently' in the proactive domain, exhibiting veridical between-group expectations. A child who engages with music at Level 5 'performs or improvises music of growing length and complexity, increasingly in time and in tune' in the proactive domain. The ability to sing a song – combining patterns and taking into account pitch, rhythm, tempo – demonstrates schematic expectations. Interestingly, they report that children from 9–15 months were engaging at Levels 3 and 4, and children as young as 21 months were seen to be engaging with music at Level 5, indicating that the internalisation of musical pattern occurs at a young age.

The studies reviewed in this section show that children absorb musical regularities from early childhood, and that these regularities inform projections about the future without the need for musical training. Furthermore, expectations increase in complexity as children grow older, as children make links between notes and sequences of increasing length. Studies on the acquisition of tonality in childhood also reflect this. For example, Krumhansl and Keil (1982) found that, using a probe-tone technique, the ability to differentiate between different tonal stabilities altered as musically untrained children grew older, whereby children aged 6-7 could distinguish between diatonic and non-diatonic tones, children aged 8-10 distinguished more strongly between diatonic and non-diatonic tones and could distinguish between triad and non-triad tones, and children aged 10-12 could make that distinction with more precision. Cuddy and Badertscher (1987) also used a probe-tone technique that accounted for pitch proximity to measure the perception of major key tonal relationships in children aged 6-12 and found that children of all ages differentiated between the tonic, triad tones, diatonic tones and non-diatonic tones. This finding was also echoed in a probe-tone study reported by Speer and Meeks (1995) in the context of ascending and descending scales in C major, whereby triad completions were preferred over other diatonic completions, which were more preferred compared to non-diatonic completions. Lamont and Cross (1994) used two variations of the probe-tone method to observe perception of diatonic relationships in children aged 6-11. Their findings were similar to that of Krumhansl and Keil (1982) in that children's perception of tonal structure developed with age, becoming less generalised and more sensitive to subtle changes. The results highlight that tonal regularities are absorbed from a young age and are thus important for the generation of expectations.

It is suggested that developmental progression is due to a combination of mere exposure, cognitive development, and enhancement of skills in other domains. However, these relate to a handful of studies, and thus establishing connections between the field of musical expectation and the broader fields of music perception and cognition should provide a more holistic overview of children's musical development.

1.5.2 Music development: perception and cognition

It is generally understood that both relative and absolute pitch processing abilities are found from infancy and throughout adulthood (Stalinski & Schellenberg, 2012), but that infants and younger children prefer to process music using absolute cues, and this shifts to relative processing as children grow older. The age at which this shift might occur is variable depending on the study's methods. Numerous paradigms have been used to investigate the development of music perception and cognition including observational research, participant-response studies that investigate implicit and explicit learning, and electrophysiological studies. Research on pitch perception in infancy, for example, utilise implicit response tasks, and they demonstrate that infants are sensitive to patterns of pitch, as evidenced by detection of contour changes (Morrongiello, Trehub, Thorpe, & Capodilupo, 1985; Stalinski, Schellenberg, & Trehub, 2008; Trehub, Thorpe, & Morrongiello, 1985). This is not surprising, since contour is crucial for speech development from infancy, although this may undergo further developmental refinement for music processing (Zatorre & Baum, 2012). Further evidence of relative pitch processing at an early age is exhibited by reports that 6-11-month-old infants recognise a transposed melody in a preferential looking paradigm (Plantiga & Trainor, 2005; Trainor & Trehub, 1992) which indicates that the infants can remember the relational structure of melodies. It has also been found that 8-month-olds can switch between relational and absolute cues depending on the task and stimuli (Saffran, Reeck, Niebuhr, & Wilson 2005). However, relative pitch and contour information is likely to stem from different neural systems, as proposed by Tew, Fujioka, He, & Trainor (2009) who found that infants and adults process occasional pitch-changes in a repeating 4-note melody using different neural pathways, arguing that both infants and adults rely on relational pitch cues. Conversely, Saffran and Griepentrog (2001) found that 8-month-old infants showed an absolute processing bias compared with a relative processing bias found in adults during an implicit learning task. Therefore, although young children can absorb information about melodic pattern, they utilise different strategies. This is supported by findings from different experimental paradigms reviewed below, including those that involve more explicit engagement, which show that an absolute processing preference exists beyond infancy.

For example, Stalinksi and Schellenberg (2010) report an interaction between age and perception. Nineteen adults and 116 children were categorised into three age groups:

5-7-year-olds, 8-9-year-olds, and 10-12-year-olds. All participants took part in a melody recognition task. Four seven-note melodies were included, two of which were present in a higher register (C and D) and two in a low register (A and B). Melodies A and B included the same notes. They began and ended on the same pitch but the intervening pitches we re-ordered, so that relations between adjacent pitches were different, as was the contour. Melodies C and D were identical to A and B but transposed four semitones upwards. In each of 16 trials, participants used a 5-point rating scale to judge perceptual similarity between pairs of melodies ranging from 1 (exactly the same) to 5 (very different). They found that 5-7-year-olds were most sensitive to absolute pitch cues rather than relative pitch cues. For example, they better recognised when the second melody in each pair was transposed rather than when it was presented with a melodic change. Furthermore, when the second melody in each pair was transposed and also consisted of a melodic change, they did not recognise the melodic change. 8-9-year-olds were also most sensitive to the transposition, but unlike 5-7-year-olds they also recognised melodic change if the second melody in each pair was transposed, demonstrating a developmental shift in perceptual processing. 10-12-year-olds judged the transposition and melodic change as equally noticeable, whereas adults judged the melodic change as more salient than the transposition, demonstrating that relational cues become more important in perception as listeners grow older.

Costa-Giomi (2003) also reports that younger children perceive melody in terms of its concrete elements prior to the perception of abstract elements. She constructed a succession of studies that investigated chord discrimination in 5-10-year-olds (Costa-Giomi, 1994a; Costa-Giomi, 1994b; Costa-Giomi, 2000), and found that children as young as five years were able to detect harmonic change in chord progressions, but that the presence of an overlaid melody affected detection accuracy, implying that relational processing which underlies the segregation of pitches into separate streams is underdeveloped. She also observed an improvement in children's perception of implied harmony at ages 8-9, whereby melody is understood in the context of harmony, indicating an understanding of musical inference, supported by processing of abstract information. Furthermore, Russo, Windell, and Cuddy (2003) found that 5-year-olds outperformed 3-4-year-olds and adults in an absolute perception task in which they had to identify a C that was embedded within a set of seven notes, which also supports the consensus that absolute processing is more dominant in childhood.

A shift in focus from concrete to abstract processing is also evident in general psychology research occurring across varying domains. Indeed, historical perspectives purport that concept formation is first constructed in terms of 'concrete-empirical' thinking prior to 'abstract-logical' thinking (Piaget, 1970; Vygotsky, 1987). Furthermore, the understanding of absolute numbers emerges prior to the understanding of how numbers connect sequentially (Michie, 1985). In language, understanding of letters precedes words, and the understanding of words precedes sentences (Drewnowski & Healy, 1977; Healy, 1976). Overall, these studies suggest that absolute and relative processing abilities are evident across the lifespan, but that children prioritise absolute information and that this bias shifts towards relative information with as they grow older.

1.5.3 General development: memory

It is understood that changes in working and long-term memory underpin perception and cognition, and is therefore central for the encoding and retention of melodic information so that it can be remembered and recalled later (Baddeley, 1986; Baddeley & Hitch, 2000). Subcomponents of working memory include span, processing efficiency and maintenance, which each contribute to musical understanding. Several reports show that the brain holds a limited number of items in working memory and that this number increases as children grow older (Bayliss, Jarrold, Gunn, Baddeley, & Leigh, 2005; Cowan et al., 2010; Cowan, Aubuchon, Gilchrist, Ricker, & Saults, 2012; Towse & Hitch, 2007).

In addition, the amount of information that can be absorbed and maintained in memory is correlated with the speed at which it is processed (Case, 1985; Case, Kurland, & Goldberg, 1982; Kail & Salthouse, 1994; Towse, Hitch, & Hutton, 1998).

A review of lifespan memory development (Ofen & Shing, 2013) from behavioural and neuroimaging evidence holds that that memory systems are predictive and interactive (Henson & Gagnepain, 2010). Ofen and Shing report that younger children rely more heavily on perceptual information compared to adults, and that they are therefore better at remembering specific perceptual details (Maril et al., 2011; Sloutsky & Fisher, 2004). They also propose that this difference could be because semantic knowledge is still developing because its informed by perception, noting that during childhood, semantic knowledge is developed via a process of episodic deconstruction, and that the episodic and semantic memory systems may become more independent with age. This idea is suggestive of perceptual change from absolute to relative processing, where repeated instances of an event eventually becomes semantic as the specific autobiographical elements decline.

Although from the research reviewed above, children's ability to absorb information is limited, they are still capable of recognising novel melodies. Schellenberg, Poon and Weiss (2017) investigated long-term memory for melody in adults and children aged 7-8 and 9-10, informed by studies that memory improves during middle childhood. They found that memory for previously unfamiliar melodies presented twice during the experiment were recognised by all age groups but with better accuracy as age increased, and that untransposed melodies were better remembered than transposed melodies. This study demonstrates that even young children can recognise a twice-heard melody after a delay of 10 minutes, despite a tendency for absolute or sensory-based processing.

1.5.4 Typically developing children: summary

Based on the above studies, it is generally suggested that children as young as five years are sensitive to common Western musical elements such as tonality and pitch proximity, with more complex developments occurring later in life. This is linked to previously identified research which suggests that exposure to music leads to the acquisition of schematic expectations including perceptual tendencies and harmonic structural knowledge (Huron, 2006). Therefore, it would be logical to postulate that the most common features in Western music would be the first to be acquired in children, with more complex and less commonly occurring aspects developing later as exposure to music increases. Furthermore, the research conducted by Voyajolu and Ockelford suggests that there is systematic developmental change in the way that musical structure is perceived to generate implications based on schematic expectations, veridical between-group expectations, and current within-group expectations. The present thesis attempts to synthesise these ideas e.g. perceptual grouping/pitch proximity (schematic), tonality (schematic), and between-group (veridical) and within-group (Gestalt-based) expectations in a way that enables the mapping of musical expectations in children by conducting empirical research with a wider range of participant age groups than seen in the studies reviewed above.

1.6 Melodic expectations in children with autism

It is evident that music is significant in the lives of many people with varying disabilities, including those with autism spectrum condition (ASC). Since music's capacity to convey meaning and emotion to listeners is founded on expectations, investigating melodic expectations in autism presents a unique window through which music cognition and perception can be understood. This also has wider applications for understanding learning and memory in autism. First, a definition of ASC is presented followed by a summary of why music is of significant value for people with autism. Thereafter, key models of perception in autism are presented, followed by a review of some key empirical studies that cover learning, memory and music perception. The summary section acknowledges the gaps in the literature and poses new questions.

People with ASC possess mild to severe neurological and behavioural deficits in emotion processing and communicative social skills (e.g. Lord et al., 2000; Rapin & Tuchman, 2008). Specific deficits pertain to the verbal description of emotions, attribution of emotions to others, and imagining the emotions of others, (Zangwill, 2013). Differences in emotion-related mechanisms between individuals with ASC and those who are 'typically developing' suggest that music may be experienced differently. Even so, research suggests that music poses considerable benefits for children and adults with ASC. For instance, engaging in musical activity can assist in reducing avoidant behaviours (Finnigan & Starr, 2010), reducing anxiety, increasing self-esteem, and improving attitudes towards peers (Hillier, Greher, Poto, & Dougherty, 2012), facilitating interaction with others, and developing verbal and non-verbal communication and social skills (Buday, 1995; Lim, 2009; Wan, Wood, Reutens, & Wilson, 2010). Music listening also enhances joint attention and engagement during learning tasks (Kalas, 2012; Simpson, Keen, & Lamb, 2013). Furthermore, research indicates that despite the deficits in emotional processing noted above, children and adults on the autism spectrum respond to music in similar ways to typically developing people (Zangwill, 2013). Allen and colleagues (Allen, Davis, & Hill, 2013) conducted a study using galvanic skin conductance as an indicator of arousal in response to music, and similar physiological responses between autistic and non-autistic control groups were found. Other studies have also found enhanced galvanic skin response in autistic individuals listening to music (Heaton, 2009; Heaton, Pring, & Hermelin, 2001; Khalfa & Peretz 2007).

1.6.1 General perception

As stated above, people with ASC feel emotional responses to music in ways that are comparable to 'typical' listeners. However, their apparent liking for repetitive musical fragments (Turner, 1999) suggests that autistic listeners perceive music differently. Thus, reviewing the literature on perception in autism is a good starting point for understanding how expectations are formed. Three key theories of perception are presented in the following paragraphs which each support the conception that autistic people perceive the world with a local predisposition. The first two are established theories which have both received substantial empirical support, namely the *weak central coherence* (WCC) model (Happé, 1999) and the *enhanced perceptual functioning* (EPF) model (Mottron, 2000; Mottron et al., 2006). The third stems from a general model of human perception, grounded in Bayesian statistical learning known as the *prediction error minimization framework* or PEM (Hohwy, 2013).

The WCC proposes that individuals with ASC exhibit superior perception for detail, but that this occurs at the expense of contextual meaning where individuals find it difficult to make connections between elements (Frith, 1989; Frith & Happé, 1994; Happé, 1999; Happé & Frith, 2006). The model originally argued that those with autism exhibit a primary core deficit in global processing, but it has since been suggested that weak global perception is a secondary outcome of a local processing bias or local 'cognitive style', and that people with autism can in fact process global information in some situations (Happé & Frith, 2006). Similarly, the EPF model proposes that global pattern detection is intact in autism but that global processing is optional. The EPF model sets out eight principles of perception that are supported by empirical research in the visual and auditory domains. In relation to musical processing, two principles of note are a) *Principle 1: The Default Setting of Autistic Perception is more Locally Oriented than that that of Non-Autistics*, where it is described that autistic people rely on local processing but can apply Gestalt principles in some conditions, which is in contrast with the typical population who rely on relational processing; and b) *Principle 5: Higher-order Processing is Optional in Autism and Mandatory in Non-Autistics*, whereby people with ASC can access physically accurate perceptual information even when primed with top-down or 'psychologically distorted' cues. Both principles are supported by empirical studies on music processing. A key difference between the models is that WCC views the local processing bias as a cognitive style that occurs along a continuum from weak coherence to strong coherence that might apply to those with and without autism (Happé & Frith, 2006), whereas the EPF model regards the cognitive differences in those with ASC as a profound difference in brain organisation (Mottron, Dawson, Soulières, Hubertm & Burack, 2006).

Conversely, the PEM is not specific to autism. Briefly, it holds that perception is based on predictive processing, whereby the mind makes predictions based on past experience and current input, and adjustments are made depending on the difference between prediction and outcome. This adjustment is known as the prediction error. Essentially, our minds continuously seek to minimise prediction error for safety and survival. Of interest is Hohwy's chapter *Precarious Prediction* in his book *The Predictive Mind* (Hohwy, 2013), where he explains how predictions can be weighted differently between top-down and bottom-up processing, leading to perceptual variance in different populations. Crucially, the bottom-up processing style exhibited by individuals with ASC facilitates more precise expectations than those who are typically developing. Therefore, at times of uncertainty, predictions made by individuals with ASC will be weighted by sensory information, whereas those who are typically developing will weight their predictions by schematic and contextual information. Hohwy's framework supports the key principle proposed by the WCC and EPF models, in that those with autism exhibit superior or preferred local processing, yet the framework presents an intriguing approach towards understanding the autistic phenotype through integrating the concepts of uncertainty and prediction. Taken together, these perceptual models present a basis upon which melodic expectations in autism can be examined.

1.6.2 Music perception

Little research has been done on musical expectations in autism, but some findings can be gleaned from studies of music perception. Take for example, an investigation into the blind and autistic musical savant, Derek Paravicini. He was born premature at 25 weeks, which resulted in irreversible damage to his retinas and a low verbal IQ of 58. Despite this, Derek has an exceptional capability for playing the piano by ear, and can rapidly recreate thousands of auditory images. Ockelford and Grundy harnessed this unusual capacity for re-creation as a means of observing musical memory in response to a first hearing of a novel composition called *Romantic Rollercoaster*, comprising a series of motifs pertaining to different combinations of between-group implications, enabling particular research questions to be explored in the context of Western music (Ockelford & Grundy, 2014). Derek was requested to play along with the piece having never heard it before. His response indicated that the more often a pattern emerged within a piece, the stronger the expectation that it would be heard again, implying that motifs are stored in working memory in much the same way as typical listeners, despite the evident differences. The findings from this study yield information about how expectations adapt in response to repetition that are otherwise problematic to uncover.

Numerous empirical studies also support the notion that people with ASC perceive music with a local precedence but can still absorb global information. The following studies present findings arising from local (e.g. contour) and global (e.g. harmonic structure) contexts. Mottron (2000) demonstrated that autistic children outperformed TD controls on a melody discrimination task where the target melody preserved the contour of the test melody but differed by one note. Additionally, there were no group differences when discriminating between a transposed target melody and a contour-violated melody.

Heaton Williams, Cummins, & Happé (2007) investigated local and global music processing in 22 autistic children aged 7-19 years and 20 matched TD controls. Participants in each group were requested to judge whether a target chord preceded by seven chords was correct or incorrect. No significant difference was found between the groups; both of which were primarily influenced by a global and local harmonic context, followed by a global context, followed by a local context. Mazzeschi, Ockelford, Welch, Bordin, Taddei, and Sirgatti (2011) reported that savants processed tonal chords more accurately than atonal chords, and were adopting listening strategies informed by harmonic structure, which shows that they have good global processing in a musical context. Quintin, Bhatara, Poissant, Fombonne, and Levitin (2013) found no significant difference between children with ASC and matched TD controls in a music block task, which assessed participants' ability to process musical structure – the task requires children to arrange a set of five plastic musical cubes into the correct slot so that the musical sequence plays correctly – the various pieces of music included multiple features such as contour, melody, harmony, and rhythm. The authors concluded that the global coherence of children with ASD aged 10-19 is no different from matched TD children and adolescents aged 7-17. Similarly, Stanutz, Wapnick, and Burack (2014) found that autistic children aged 7-13 years showed superior short-term pitch memory in a task that required them to discriminate isolated tones and superior long-term melodic memory in a melodic recall task.

In summary, these findings contribute to the overall conception that autistic children perceive music using a combination of enhanced local processing and typical global processing. In applying zygonic theory to these results, it is expected that those with ASC will exhibit intact schematic expectations and weaker veridical expectations, compared to typical listeners, which may explain the reported fondness for musical repetition in autism.

1.6.3 Memory and learning

Many studies indicate that the perceptual differences in autism are underpinned by differences in memory and learning, which may also give context to the study of expectations. It is widely recognised that autistic people exhibit a deficit in episodic memory and intact semantic memory, and that this is supported by research that utilises varying paradigms and traverse many domains. For example, the Historical Figures Task was utilised by Gaigg, Bowler, and Gardiner (2014), who recruited 22 adults with ASC and 22 TD adults and asked them to recount the order of historical figures according to either the chronological sequences in which they existed in history, or to a random order that was shown to them on a screen. The former was designed to trigger semantic memory, and the latter was designed to trigger episodic memory. They found that participants with ASC performed less well than TD controls in the episodic memory task and equally well on the semantic memory task, indicating processing difficulties pertaining to the episodic memory system for those with ASC. However, it is possible that participants had prior chronological knowledge of the historical figures, which could have instead activated semantic memory thereby influencing responses.

Remember/Know recognition experiments demonstrate impairments in episodic memory (remembering), but not semantic memory (knowing). Bowler, Gardiner and Grice (2000) tested remembering and knowing in adults with Asperger's, and 'typical' controls. During a study phase, participants were given a list of words to remember, followed by a test phase during which they were presented with words from the study list and words from a distractor list. Participants indicated whether they had seen the word before (YES or NO) and if the response was yes, they were to indicate whether their memory related to TYPE A – remembering the word and the context in which it was acquired – or TYPE B – knowing the word but in the absence of contextual information. They found that adults with Asperger's recognised the same number of words as 'typical' participants, but that they reported more instances of knowing and fewer instance of remembering compared with typical participants, implying that those with Asperger's rely more on semantic memory. Bowler, Gardiner, and Gaigg (2007) tested the strategies that participants might use during a Remember/Know procedure in three experiments. First they introduced a divided attention experiment which involved a low/medium/high tone identification task in addition to the word memory task. They found that people with Asperger's and controls were similarly affected by the distraction, which reduced instances of remembering, suggesting that that both groups were utilising similar processes. Secondly, the modality between study and test was altered so that words were presented visually but then half of the words were tested visually and the other half were tested auditorily. The order was swapped for half of the participants. Again, they found that participants were influenced by the manipulation in a similar way. Lastly, they incorporated a lexical decision task into the study phrase, and again found similarities between both groups of participants. These findings are important because although participants with Asperger's always showed more instances of remembering, triggered by episodic memory, they responded similarly to controls during each task manipulation, demonstrating that the episodic memory system itself may operate in a typical way. Crane and Goddard (2008) examined autobiographical episodic and semantic memory of adults with autism and typical adults using an autobiographical fluency task, a structured interview, and a memory narrative task, which assessed memories from across various time-points in an individual's life. They found that semantic memory was spared in autistic adults but that episodic memory was impaired. Specifically, the number of memories recalled by typical adults peaked when recalling from secondary school age, but the number of memories recalled by autistic adults did not differ as a function of time.

These studies show that episodic memory is atypical in autism, where access to the episodic system is impaired, but that the memory system itself may be similar to that of the typical population. However, the methods described above do not capture the temporality of real-world processing in the same way that music does, and thus, capturing and differentiating episodic and semantic memory systems through expectation in music may offer a more fruitful and ecologically valid method of understanding the development of memory.

Also of interest to the understanding of how expectations function is implicit learning or statistical learning, which is characterised as learning in the absence of intention (Brown, Aczel, Jiménez, Kaufman, & Grant, 2010). The concept of implicit learning is similar to statistical learning which has been touched upon in section 1.4 of this literature review which outlines key cognitive models of musical understanding. Historically, it has been thought that the deficit in implicit learning for environmental regularities may account for the atypical perceptual profile of those with autism, particularly in the social cognitive context, since they have been reported to exhibit a greater propensity to utilise explicit strategies in social cognition (Klin, Jones, Schultz, & Volkmar, 2003), and implicit mapping and learning of others' behaviour (Vivanti & Rogers, 2014). However, more recent studies demonstrate that in fact, implicit learning of local and global regularities in autism is shown to be intact in varying domains that traverse visual and auditory processing, such as spatial context and visual sequential information in children (Barnes et al., 2008), implicit motor skill learning and memory consolidation (Nemeth et al., 2010), and spoken language (Hudac et al., 2018; Tesink et al., 2009). Brown et al. (2010) tested autistic adults on a range of probabilistic implicit learning tasks which incorporated social elements, motor coordination, visual context and learning of artificial grammar, and found no evidence for an implicit learning deficit. They suggested instead that processing difficulties may lie in how implicitly learned knowledge is applied to real-world processes, which has since been demonstrated by Izadi-Najafibadi, Mirzakhani-Araghi, Miri-Lavasani, Nejati, & Pashazadeh-Azari (2015), who tested implicit and explicit motor learning of 30 children with ASC aged 7-11 years and 32 matched controls using a serial reaction time task, where children were presented with varying sequences of four colour blocks, and had to match the colour with a pre-determined keyboard button. Only the explicit learning group were given a copy of the colour block sequence. Results revealed that ASC and TD children both demonstrated implicit learning, but that only TD children showed explicit learning, suggesting that ASC children can learn motor skills implicitly, but they have difficulties with explicit application. Additionally, a meta-analysis conducted by Foti, De Crescenzo, Vivanti, Menghini, & Vicari (2015) demonstrates that motor learning is preserved in children and adults with a formal diagnosis of autism.

DePape, Hall, Tillmann and Trainor (2012) measured several aspects of auditory processing found in music and speech in 27 adolescents with autism and 27 controls. During a metrical structure task, participants were familiarised with 15 seconds of melody which either had a Western-typical simple meter or a complex meter. Each familiarisation was followed by a 30 second test melody that either contained a simple or complex meter. Participants had to rate how well the meter in the familiarisation and test melodies matched (ranging from 1 = very well matched; to 4 = poorly matched). It was found that ASC participants were less sensitive to differences between the two meters compared with TD controls. A second music-based task assessed implicit harmonic learning where adolescents were presented with an 8-chord sequence and were requested to indicate whether the 8^{th} chord (target chord) was in a piano or harp timbre. In half of the sequences, the target chord was the tonic, and in the other half of sequences, it was the dominant. Their reaction times were measured as a proxy for perceptual focus – harmonic or sensory. Results showed faster response times for the expected chord endings in adolescents with ASC and controls, indicating that implicit harmonic priming was evident in both groups. They suggest that skills acquired early in development are disrupted in autism, which may explain why metrical categorisation seems less developed as it may emerge prior to the acquisition of tonal and harmonic information, as it is more important in speech and social communication.

1.6.4 High-functioning autistic children: summary

It is evident from this literature review that music positively impacts the lives of children with ASC, and although they may perceive music to be pleasurable in the same way as their ‘typical’ peers do (Zangwill, 2013), expectational processes are likely to be different, in tandem with reported differences in perception and memory. For example, it is well established that people with autism tend to rely more on the senses, thus exhibiting a local processing precedence. This pertains to several domains including music listening. It is not clear why this occurs, but is thought to be due to atypical episodic memory, rather than a deficit in implicit learning, since those with ASC are able to absorb environmental regularities. However, many studies on memory and perception in autism are static, therefore studying melodic expectations as they unfold over time in children with autism should uncover the intricacies of the autistic person’s musical mind in a novel way, that considers dynamic responses to pattern and repetition within a ‘closed’ structural context. It is hoped that the findings from the present research will inform education and psychology research and practice, including teaching and learning in educational contexts, and cognitive modelling of musical understanding.

1.7 Research questions and hypotheses

1.7.1 Research questions

The objectives outlined above are broken down into four research questions and are presented in Table 1.2 at the end of this chapter:

1. Does melodic repetition influence the relationship between schematic, veridical and within-group expectations cumulatively in ‘typical’ adults?

2. What are the normative age trends in children aged from 6-17 in terms of the development of schematic, veridical, and within-group melodic expectations, and how do those expectations interact in response to melodic repetition?
3. How does the ‘atypical’ development of children with high-functioning autism influence the interaction between schematic, veridical and within-group expectations in a repeated melodic context?
4. Is there a difference in the developing interaction between different forms of expectation between each participant group?

1.7.2 General hypotheses

The following section presents a general hypothesis for each question. Once the methodological design, procedure, participants, and stimulus construction have been discussed in chapter 2, detailed hypotheses pertaining to the stimulus will be presented.

- Does melodic repetition influence the relationship between schematic, veridical and within-group expectations cumulatively in ‘typical’ adults?

It is hypothesised that in adult listeners, the interaction between schematic, within-group and veridical expectations will change systematically in response to melodic repetition in a way that reflects integration of information from short-term memory into long-term memory. As indicated by several priming studies that demonstrate the resistance of schematic expectations (Bigand, Tillmann, Poulin-Charronnat, & Manderlier, 2005; Marmel, Tillmann, & Delbé, 2010; Tillmann & Bigand, 2010) and conjectures made by Thorpe et al. (2012), schematic and within-group expectations will adjust in response to melodic repetition but will remain ‘intact’, where the projected probability of surprising/irregular upcoming musical events may continue to be surprising in response to repeated exposure, but the effect will dampen over time. Simultaneously, veridical expectations (within-pieces and between-pieces) will become cumulatively more dominant in response to melodic repetition as listeners' familiarity increases. Second, it is hypothesised that listeners may reach a saturation point at which veridical expectations completely dominate, and listeners can fully predict what is coming next. It is not yet clear after how much exposure a saturation point would appear and is something to be explored in the discussion. Furthermore, the halting of melodic repetition will change the direction of the interaction between the forms of expectation, whereby, as melodic memory declines over time, veridical expectations will become less dominant and schematic and within-group expectations will come to the forefront.

- What are the normative age trends in children aged from 6-17 in terms of the development of schematic, veridical, and within-group melodic expectations, and how does this influence the interaction between said expectations in response to melodic repetition?

It is hypothesised that schematic and within-group expectations will develop before veridical expectations in accordance with cognitive development, mere exposure, skill development (Schellenberg et al., 2002), and a shift in preference from absolute to relative perception (Stalinksi & Schellenberg, 2010). Typically developing children's sensitivity to perceptual complexity and length of melodic sequence will increase with age, where expectations will stem first from local cues (such as pitch proximity, pitch range, pairs of notes) and will proceed to be influenced by global cues (such as attending to longer sequences of notes, awareness of pattern repetition and phrase boundaries). Thus, development in its various forms will influence the way in which expectations interact in response to melodic repetition. For example, young children will exhibit local processing preferences which is indicative of memory constraints, whereas older children will exhibit global processing preferences which is indicative of developed memory processes that supports the absorption and retention of veridical information. It is acknowledged that Voyajolu and Ockelford's paper (2016) on developmental levels indicates that veridical expectations might emerge first when children are engaging in independent soundmaking, but it is predicted that in the context of making probability-based judgements, veridical expectations will take longer to develop in accordance with the suggested absolute to relative perceptual shift.

- Children with high-functioning autism exhibit atypical memory function. How is this reflected in the interaction between schematic, veridical and within-group expectations in a repeated melodic context?

It is hypothesised that autistic children will exhibit a preference for local-level pitch processing, whilst also maintaining typical global processing abilities (Mottron et al., 2006; Heaton et al., 2007; Quintin et al., 2013). Specifically, the main source from which expectations arise will be those which are schema-driven, stored in long-term memory, and these will be represented as consistent response patterns pertaining to deep-rooted local aspects of melody such as tonality and the low-level function of pitch-proximity. As within-group expectations are underpinned by higher-order perceptual processes that span several pitches, they will be less influential for autistic listeners compared to TD listeners. For example, the disruption of an emerging melodic pattern that is tonally unstable may be overridden by expectations pertaining to (a more tonally stable pitch relationship) tonality. However, that is not to say that autistic children will not recognise phrase and melody repetition, since due to superior abilities in sensory pitch processing they may exhibit an enhanced ability to remember pitches and perhaps phrases that have gone before (e.g. Bonnel, Mottron, Peretz, Trudel, Gallun, & Bonnel, 2003; Heaton, 2005) – yet due a local perceptual bias, veridical expectations will adjust at a slower rate in those with autism, and therefore a cumulative effect of repetition may not be evident in the ratings.

- Is there a difference in the developing interaction between different forms of expectation between each participant group?

In terms of typical development, the cumulative influence of melodic repetition on expectations will increase as participants grow older, reflective of typical memory development and increased exposure, where listeners can focus on musical chunks of increasing size that move from short- into long-term memory. Similar to the youngest TD children, melodic repetition will not influence expectations cumulatively in autistic children. However, unlike the youngest TD children, autistic children’s expectations will be influenced by high level schematic features, indicating a difference in how expectations are formed between autistic children and typically developing children.

Table 1.2 Aims, objectives and hypotheses.

<table>
<tr><td colspan="4">Main aim

To empirically investigate the role that melodic expectations play in the perception of melodic repetition as a result of ‘typical’ and ‘atypical’ development.</td></tr>
<tr><td>Objective 1

To empirically investigate the changing interplay between various sources of expectation in the context of melodic repetition in ‘typical’ adult listeners.</td><td colspan="3">Objective 2

To identify how the interaction between different forms of expectation evolves as a result of ‘typical’ and ‘atypical’ development in the context of melodic repetition.</td></tr>
<tr><td>Research question 1

Does melodic repetition influence the relationship between schematic, veridical and within-group expectations cumulatively in ‘typical’ adults?</td><td>Research question 2

What are the normative age trends in children aged from 6-17 in terms of the development of schematic, veridical, and within-group melodic expectations, and how do those expectations interact in response to melodic repetition?</td><td>Research question 3

How does the ‘atypical’ development of children with high-functioning autism influence the interaction between schematic, veridical and within-group expectations in a repeated melodic context?</td><td>Research question 4

Is there a difference in the developing interaction between different forms of expectation between each participant group?</td></tr>
<tr><td>Hypothesis 1

a) Melodic repetition will cumulatively influence expectations. Schematic and within-group expectations will remain intact. Veridical expectations (between- and within-pieces) will adjust with each stimulus exposure as listeners become more aware of the repetition.
b) This may lead to an eventual point after which veridical expectations can no longer adjust and the listener can consciously predict what will come next.
c) Veridical expectations will alter as a function of recency, reflective of memory decay.</td><td>Hypothesis 2

a) Schematic and within-group expectations will develop before veridical expectations. Expectations will first be based on absolute, low level information (e.g. pitch proximity, pitch range, pitch intervals) and then progress to relative, high level information (pattern repetition, pattern continuation, longer sequences of notes).</td><td>Hypothesis 3

a) Autistic children prefer to attend to local-level pitch processing without detriment to global pitch processing.
b) Expectations will be based primarily on deep-rooted schematic expectations
b) Due to a local perceptual bias, veridical expectations will adjust at a slower rate in autism compared with typical listeners, reflecting atypical veridical memory.</td><td>Hypothesis 4

a) The cumulative influence of melodic repetition on expectations will increase as participants grow older, as reflective of typical memory development and increased exposure, where listeners can focus on musical chunks of increasing size that move from short- into long-term memory.
b) Similar to the youngest TD children, melodic repetition will not influence expectations cumulatively in autistic children. However, unlike the youngest TD children, expectations will be influenced by complex schematic features.</td></tr>
</table>

2 Methods

This chapter outlines the methodological approach, and describes the research design including information about participants, materials, and apparatus; and the data collection procedure and prepping the raw data for analysis. The rationale behind various methodological choices will also be discussed with reference to existing literature.

2.1 Design

Although expectations are a crucial component of musical understanding, they are generally fleeting processes and are thus difficult to capture using qualitative measurement tools such as interviews, focus groups or participant observation. Hence, as the literature presented in Chapter 1 indicates, the measurement of musical expectations is usually limited to quantitative methods (Huron, 2006). The most commonly reported are the probe-tone technique, the production method, the betting paradigm and the continuous response method, each of which will be summarised in this section, followed by a discussion of why the continuous response method is most suited to the current study.

2.3.1 Measuring expectations

The *probe-tone technique* requires participants to judge the ‘goodness of fit’ of a tone that follows a sequence of notes or chords in a given tonal context (Krumhansl & Kessler, 1982; Krumhansl & Shepard, 1979). Usually the same musical passage will be presented several times followed by a different probe tone, resulting in a detailed map of listeners’ preferences for multiple continuations, some of which may be judged as equally fitting. The probe tone has been utilised with various musical contexts - from two tones to complete musical works - to investigate the expectations of western listeners (e.g. Schmuckler, 1989; Krumhansl, 1995b, 1997; Cuddy & Lunney, 1995; Thompson, Balkwill, & Vernescu, 2000; Ockelford & Sergeant, 2013), Chinese listeners (Krumhansl 1995a), Finnish listeners (Krumhansl et al., 1999) and South African listeners (Eerola, Louhivuori, & Lebaka, 2009). There are two key critiques. Firstly, the probe-tone can be time-consuming for experimenter and participant, which could result in unreliable data from some groups of participants such as young children or those with a learning difficulty. Secondly, probe-tone ratings may be affected by perceptual closure because the music must stop each time a probe-tone is judged. Bret Aarden (2003) reported that listeners have a separate set of expectations for 'phrase-final' contexts in which the tonic is the most commonly occurring scale degree compared with 'mid-melody' contexts where the dominant is most common.

The *production method* requires listeners to sing or produce a continuation on an instrument after being presented with either a two-tone interval (Carlsen, 1981; Schellenberg, Purdy, Adachi, & McKinnon, 2002; Schmuckler, 1989; 1990; Thompson, Cuddy, & Plaus, 1997; Unyk & Carlsen, 1987) or incrementally increasing musical sequences (Thorpe et al., 2012). Advantages of the production method are that it can reveal the participant's strongest expectations more quickly than the probe tone method; however, this interpretation could be misleading as expectations may be multiple. Furthermore, it requires participants to be able to sing in tune or to play an instrument, which is not always possible.

The *betting paradigm* allows the experimenter to calculate subjective probabilities for a variety of continuations. Participants place bets according to how likely it is that a target pitch would follow an interval or longer musical passage. For example, participants hear the first note in a melody and place bets on what they think will be the second note before it is revealed. Then the first and second notes are played, and participants place bets on what they think the third note will be, and so on. Participants are given time to try out different continuations using a keyboard sampler or notation software before placing their bets. The spread of bets can be interpreted as a confidence marker where the more even the spread of bets, the less confidence the participant has in a single specific predicted continuation. However, placing numerous bets about different expected continuations is reported to take anywhere between thirty seconds to three minutes per pitch event (Huron, 2006, p.48; Manzara et al., 1992), a time-consuming method which reflects conscious deliberation about expectations, potentially affecting the ecological validity.

Researchers using the *reaction-time priming method* typically ask participants to make speeded judgements in response to temporally occurring experimental stimuli. It is well-established that the processing speed and efficiency of a stimulus or event is positively related to how well it is related to the preceding context. For example, in musical terms, the processing of a target chord is faster and more accurate when it follows a related prime chord or prime sequence of chords. Tonal priming experiments have shown that harmonic priming is faster and more accurate than repetition priming (Tillmann, Bigand, Pulin-Charronnet, & Manderlier, 2005) even when controlling for spectral frequencies and using pure tones (Marmel, Tillmann, & Delbe, 2010), and it is suggested that this is because harmonic priming activates schematic long-term memory which is automatic and implicit. Studies also report that priming of more related chords (e.g. where the target is a tonic) compared to less related chords (i.e. where the target is a subdominant) facilitates faster processing even when unrelated targets occur more often and more recently (Bigand, Madurell, Tillmann, & Pineau, 1999; Bigand et al., 2003; Heaton et al., 2007), and that the influence of schematic expectations (harmonic priming) are stronger than veridical expectations (repetition priming) in the context of chord pairs (Justus & Bharucha, 2001) and complete musical structures (Tillmann & Bigand, 2010).

Interestingly, Tillmann & Bigand (2010) found that veridical expectations had some influence on task performance by decreasing the processing cost of less-related targets compared with related targets, indicating that repetition effects may influence sensory level processing, but are not robust enough to tap into cognitive processing. Priming methods are therefore suitable for exposing implicit processes relating to schematically learned information about tonal structure of a fragment or piece of music, which show overall that cognitive priming is more robust that sensory priming. However, more fine-grained changes to expectations such as those occurring in response to melodic features other than tonality (i.e. melodic patterning and contour) have not been measured using priming experiments. Furthermore, it seems that more subtle changes in expectations (such as within-groups, veridical within and between pieces) would be more difficult to expose, since they are not necessarily implicit processes.

Unlike the above-mentioned techniques, the *continuous response method* requires participants to provide continuous ratings in response to a musical excerpt or piece without the need for pauses. Therefore, longer musical excerpts can be used and expectations can be gleaned continuously for an entire piece of music. One such measurement tool involves turning a 256-degree pointer known as a Continuous Response Digital Interface (CRDI) to the desired marker, usually ranging from very unexpected on the left, to very expected on the right. A more recent version has been developed by Evangelos Himonides (Himonides, 2011) known as the Continuous Response Method Apparatus or CReMA, whereby users move their forefinger from left to right across a touch-sensitive ribbon, and in some cases, depending on the equipment, pressure values can also be extracted which are indicative of confidence values. The CReMA's success in measuring expectations in real-time was demonstrated by Trower (2011), where adults provided expectancy ratings in response to melodic repetition by utilising the CReMA as a rating scale ranging from 'very unexpected' on the left to 'very expected' on the right. A limitation of to the continuous response method is that researchers can only collect data about responses to the pitches that occur in a given stimulus or stimuli, whereas the probe-tone method and betting paradigm expose multiple potential expectations from a single pitch event. A further limitation relates to the lag that occurs between a participant hearing a pitch, considering their response, and making their response. This poses a challenge during the analysis stage as the process of matching participant responses to stimulus events risks potential researcher bias. Furthermore, missing data is more likely to occur from a continuous response method compared to the methods reviewed above.

With the current study's research questions in mind, the continuous response paradigm based on the CReMA is most suitable for several reasons. Unlike the production method, the continuous response method does not discriminate based on musical ability. In terms of procedure, continuous response methods enable melodic repetition to be achieved within a short time-frame unlike the probe-tone method and betting paradigm. This will minimise potentially confounding concentration issues among young children and those with additional needs. Moreover, the CRDI has been reported as being a successful tool for assessing children's aesthetic responses to music (Paul, 2003), and although the CReMA has previously only been used by adult participants, it should be easier to operate than its predecessor. Furthermore, it is expected that the CReMA's touch-sensitive feature will appeal to children in this current age of electronic gadgets. Similarly, children with autism benefit from touch-screen technologies such as mobile phones and tablets (McNaughton & Light, 2013), so presumably a rating tool based on the CReMA will also be operable for those with autism.

2.3.2 Repeated measures design

Bearing in mind the present study's research questions and objectives, *repetition* is a key focus. Accordingly, a repeated measures design was employed so that changes in participants' perceived expectations (the dependent variable) can be observed in response to repeated exposures of the same melodic stimulus (the independent variable). Perceptual differences in response to repetition can only occur through experiencing repeated measures, a design that requires each participant to undergo the same experimental conditions. A design that does not incorporate repeated measures – such as a between-groups design which allocates separate participant groups to different conditions – would not provide an opportunity for the potential cumulative effects of stimulus repetition to evolve. Furthermore, as each participant is exposed to the same procedure, comparisons can be made across participant groups.

2.4 Participants

Taking all three research questions into account, a key aim is to compare the melodic expectations of different participant groups, namely; (a) typically developing adults, (b) typically developing children, and (c) children with autism spectrum condition, or ASC. Although musical meaning is rooted in expectation, research concerning expectations among participant groups (b) and (c) is minimal or non-existent. An a priori sample size for five participant groups was calculated using G*Power software with an estimated effect size of 0.25, and was estimated to be a total of 205 for repeated measures across 2 timepoints (sessions), and 65 for repeated measures across 8 timepoints (trials), thus the target sample was 41 participants per group.

2.4.1 Rationale for typically developing sample – adults

The recruitment of adults is to develop the conjectures and findings of Ockelford (2006) and Thorpe et al., (2012) to understand how schematic, veridical and within-group expectations adjust in response to repetition in typical adult listeners, which has not yet been studied. Furthermore, adults represent cognitive maturation with which developmental comparisons can be made. The majority of research on musical expectations focuses on adult listeners, and thus it is helpful to build on an already established platform when considering expectations from a new approach such as the developmental one proposed here. It will also inform hypotheses about the developmental progression of expectations, thereby helping to focus the analysis.

2.4.2 Rationale for typically developing sample – children

Children aged 6-8, 9-12, and 13-17 were recruited so that the developmental trends in early, middle and late childhood can be observed. The selected age range was informed by psychology literature on memory development. As there is little research pertaining to the development of musical expectations, an alternative way of exploring such expectations is to situate them within the broader categories of *semantic memory* and *episodic memory* (Huron, 2006), for which an existing body of literature can inform initial exploration (see chapter 1, section 1.3 for a review). Associating schematic and veridical expectations with semantic and episodic memory helps to make informed methodological decisions. For example, episode foresight, otherwise known as 'mental time travel' is said to develop substantially between the ages of 3 and 7, with the emergence of core factual information at 3-4 years, followed by the emergence of high-level aspects such as temporal and spatial processes between ages 4-7 (Martin-Ordas et al., 2014; Picard, Cousin, Guillery-Girard, Eustache, & Piolino, 2012). With these figures in mind, it can be reasoned that the lower age limit in the present study should be around 6-7 years old to ensure a certain level of task comprehension which includes an ability to think about the future based on the past. [3]

The age range of children in the present study ranges from 6-17, covering early, middle and late childhood. This is wider than generally seen in quantitative studies of

[3] It is recognised that music cognition is a form of mental time travel as it requires listening ahead and formulating projections based on past experience (Margulis, 2007; Bailes, Dean, & Pearce, 2013).

music perception and cognition, possibly because the rate of music-developmental change slows once children reach 11-12 years of age (Lamont, 2016). By around 12 years, a context-independent understanding of pitch relationships (Paananen, 2006) and high-order perceptual principles (Schellenberg et al., 2002) have emerged, which could explain why the development of music perception and cognition in adolescents is currently understudied. The focus tends to be around 4-11 years (Hargreaves & Lamont, 2017; Lamont, 2016; Schellenberg et al., 2002; Schellenberg, Poon, & Weiss, 2017; Schwarzer, 1997; Stalinski & Schellenberg, 2012; Weiss, Schellenberg, Trehub, & Dawber, 2015). However, developmental changes still occur during adolescence, thus the present research aims to track this through investigating expectations in the proposed age groups.

2.4.3 Rationale for typically developing sample – gender and musical ability

Consideration was given to gender and musical ability as these factors could affect expectancy ratings. Although the study of gender differences in musical memory has only received little attention, some differences have been found. Thorpe et al. (2012) reported that the melodic expectations of men and women differed for descending intervals but not for ascending intervals, and that women tended to expect melodic repetition more so than men. In addition, men's confidence ratings were consistently higher than women's, which may have been because men's predictions were correct more often, encouraging a growth in confidence. The authors speculate that the gender difference in expectations for descending intervals could be due to the difference in octave range between men and women and differences in hemispheric activity during music listening (Koelsch, Maess, Grossmann, & Friederici, 2003). Conversely, Miles, Miranda and Ullmann (2016) found that women were significantly quicker at recognising familiar melodies in a novel vs familiar melody discrimination task, but there was no difference between men and women in accuracy. Participants were 24 men and 24 women, and each gender group was split evenly into musically trained (4 years or more of private lessons) and untrained (1 year or less). Miles, Miranda, and Ullman (2016) suggested that enhanced declarative memory in women was the primary reason for their results. It is reported elsewhere that auditory episodic memory is superior in women, but studies tend to use verbal rather than musical measures (Pauls, Petermann, & Lepach, 2013). These studies incorporate different methods that lead to different outcomes, therefore there may be gender differences in the development of melodic expectations in response to repetition, but the nature of those differences is unclear.

Furthermore, although untrained listeners can perceive music's structural complexities, and tensions and relations through mere exposure to music (Bigand & Poulin-Charronnat, 2006), musical expertise as measured by formal instrumental instruction has been reported to influence schematic expectations (Anta, 2013; Guo & Koelsch, 2016; Pearce, Ruiz, Kapasi, Wiggins, & Bhattacharya, 2010). Therefore, in the current study, participants with formal musical training might exhibit enhanced working memory performance (Pallesen et al., 2010) and episodic memory performance (Cohen, Evans, Horowitz, & Wolfe, 2011) and would therefore recognise the stimulus repetition more quickly than those without training. With these studies in mind, an equal balance of gender, and those with and without formal musical training was intended for all participant groups, however, this was not always possible due to recruitment styles such as through word of mouth and snowballing.

2.4.4 Rationale for children with ASC

Examining the musical expectations of non-typical populations such as those with autism can help to glean an understanding of how different cognitive processes might colour the musical experience. By observing the impact of particular deficits on music perception, the dismantling of cognitive mechanisms into constituent parts is enabled, and one can start to rebuild a picture of how the constituent parts integrate. Particularly in autism, cognitive deficits can exist alongside intact or enhanced capabilities - such as superior local processing and intact global processing (Heaton, 2009; Mottron et al., 2006) – but these differences are sometimes disguised due to the perceptual strategies that are specific to autism (Mottron, Dawson, Soulieres, Hubert, & Burack, 2006), and therefore, understanding these different mechanisms is useful for the development of musical tools and skills that are relevant in educational and therapeutic contexts and amongst people with varying developmental trajectories.

For example, despite widely-reported deficits in emotion recognition and communication skills (Lord et al., 2000; Rapin & Tuchman, 2008), people with autism can recognise emotion in music, enjoy listening to music and are emotionally and physiologically affected by music in ways that are similar to typically developing people (Allen, Hill, & Heaton, 2009; Allen, Walsh, & Zangwill, 2013; Quintin, Bhatara, Poissant, Fombonne, & Levitin, 2011; Gebauer, Skewes, Westphael, Heaton, & Vuust, 2014). It is reported that although emotional responses to music might be similar, the neurological differences indicate enhanced analytical responses to music and more cognitively demanding decoding strategies (Gebauer et al., 2014). Furthermore, it is reported that the increased presence of absolute pitch and superior memory for sensory information in autism is correlated with a perceptual preference for local processing, suggesting again that although music is enjoyed by people with autism, the way in which that enjoyment is achieved cognitively and perceptually is quite different from typical listeners. This suggests that there are different processing strategies for achieving the same outcomes, and therefore in situations where music can enhance a person’s life such as music therapy or music education, knowledge of such strategies could improve interaction and deepen the connection between practitioner and client and thus improve the therapeutic impact.

Although it has been reported that expectations are fundamental for making sense of music, only one study has examined the musical expectations of autistic children. Pamela Heaton and colleagues (Heaton et al., 2007) adopted a priming method extracted from the work of Tillmann and colleagues (Tillmann et al., 1998), and demonstrated that children were sensitive to harmony on a local and global level, indicating that global processing (and an understanding of Western harmony) is intact in children with ASC. However, this does not address pattern perception between and within groups of notes, and continuation of patterns within groups of notes, which are both crucial music-structural ingredients that are cognised both locally and globally (Thorpe et al., 2012). With this in mind, the continuous response method used in the current study should shed light on how repeated exposure can affect expectations within and between groups over time in a local and global context.

Recruitment of girls and boys with ASC ranged in age from 8-15 in the present study. Age was deemed an unreliable indicator for predicting how participants with ASC will respond in the experiment, therefore it was not the main criterion for this participant group. This is due to a diverse range in intellectual abilities, stemming from uneven or atypical cognitive development including dissociations between verbal and non-verbal skills (Joseph, Tager-Flusberg, & Lord, 2002; Kuschner, Bennetto, & Yost, 2007). Furthermore, considerable variability in the reading skills of children with autism has been demonstrated (Nation, Clarke, & Wright, 2006; Whitby & Mancil, 2009). Hence, cognitive development is often indicated by non-verbal mental age, rather than chronological age alone (Luyster, Lopez, & Lord, 2007). Based on this, the lower age limit in the present study was set slightly higher at eight years old, rather than six years old as seen in the TD participant group. A secondary reason for amalgamating autistic children into a single age category is due to the difficulties with recruiting a sufficient number of high-functioning children for statistical power, within a reasonable time-frame for completing the research.

2.4.5 Rationale for ASC sample – gender and musical ability

As with neurotypical participants, gender may be a potential confounding variable when considering participants with autism. It is widely cited that there is ratio of 4:1 males to females in the autistic population (Fombonne, Quirke, and Hagen, 2011), although more recent research suggests that this proportion is incorrect due to under-reporting and mis-diagnosis of females with autism due to a range of neurological and biological differences to males (Kirkovski, Enticott, & Fitzgerald, 2013). A revised ratio has been estimated as 2 to 3:1 males to females, however it is suggested that the diagnosis of autism is still tailored to suit male characteristics (Lai, Baron-Cohen, & Buxbaum, 2015). There is no literature to suggest that there are differences in the way that music is perceived by boys and girls with autism, however, this will be explored during data analysis. Autistic children with perfect pitch (Heaton, 2003) were excluded from participating in the study, as this is likely to produce ceiling effects and confound the results. Children or their care-givers were asked if children possessed perfect pitch prior to commencing the study. Furthermore, participants with ASC were selected with a range of musical training ranging from no formal training up to eight years of formal tuition.

2.4.2 Recruitment

Adults were recruited through snowball and convenience sampling methods including word of mouth, direct contact with friends and colleagues, and advertisements on social media websites such as Facebook and Twitter. Such methods were useful for this participant group as the only recruitment criteria were that males and females with a range of musical abilities were enlisted, and this variation in people was accessible through immediate contact with friends and family. Typically developing children were recruited from schools located across the West Midlands and London. From the two hundred schools contacted by telephone and email, six schools agreed to take part, four of which participated because of conversations with colleagues and friends. Contact with schools was the preferred method of enlisting children in terms of ethical considerations, because safeguarding procedures are in place which protect both child and experimenter. Furthermore, several children can be recruited from a single location. Autistic children were enlisted from four schools from the West Midlands. Additionally, participants were enlisted via the Autism Research Centre in association with the University of Cambridge whereby a database of potential participants could be accessed – this involved submitting a research application consisting of a Research Protocol, Information for Participants, Participant Consent form, and ARC Participant Request Form prior to advertisement via the ARC. Recruitment via Autism West Midlands also involved a similar vetting process prior to being advertised on the research section of their website.

The experimental design may have discouraged some schools from agreeing to participate, in that two separate visits were to be made which may have been viewed as disruptive to the school day. The recruitment of autistic children was most problematic, likely because there are fewer sources from which to recruit compared with the number of mainstream schools in the UK. There was no monetary compensation offered in exchange for participating, but schools and individuals were offered a written report outlining the findings once the data had been collected and analysed. Nonprobability sampling (e.g. non-random sampling) is limited due to potential sample bias which leads to difficulty in generalising the findings to a wider population. However, it is economical in terms of cost and time, and in the case of the current study, a limited budget and strict timeframe meant that the research would not otherwise be possible.

2.5 Materials

2.5.1 Audio materials

The experimental materials consist of one stimulus melody, one practice melody and a set of nine unmelodic distractor sequences. The decision to include only one stimulus and not multiple stimuli was due to the repeated measures design and the participants. The stimulus is to be repeated multiple times during two experimental sessions, and responses are provided for 25 pitch events during each stimulus repetition which requires a high level of concentration. Therefore, as some participants are as young as 6 years and others are recognised as having an intellectual disability, the amount of concentration time during the rating task should be kept as short as is necessary. This is for the comfort of the participants as well as the validity of the data, since distracted ratings may confound the results. In accordance with the research questions, the materials should adhere to the following criteria:

a) Pitch relationships from within the Western musical idiom are the focus of the study; therefore, other musical elements such as rhythm, dynamics and tessitura are kept 'neutral'. In this case, a piano timbre was chosen as it is a familiar timbre within Western music.
b) Pitches are limited to the major diatonic scale; a familiar framework within Western music whereby unambiguous tonal implications can quickly be established.
c) The stimulus should be a single melodic line to avoid the activation of complex expectations that may arise from harmonic relationships.
d) The stimulus should be novel so that listeners can provide a baseline response that is unaffected by veridical expectations generated from previous exposures.
e) The stimulus should include groups of notes that are repeated or transposed as a means of observing different forms of expectation such as those between groups and within groups.

2.5.1.1 Stimulus construction

The stimulus melody used by Thorpe et al. (2012) was appropriate for use in the current study, given that the criteria were similar for both studies. As shown in Figure 2.1, the stimulus is a 26 note single melodic line, made up of 24 crotchets and two semibreves.

Phrase A occurs four times and a transposed version of phrase B appears twice.

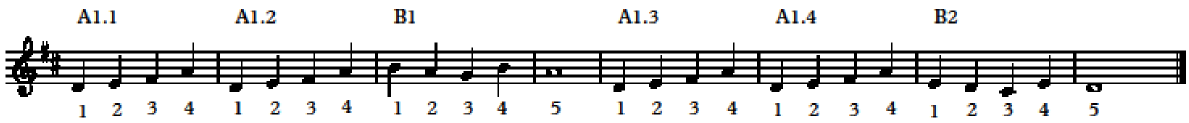


Figure 2.1. The experimental stimulus conceived in Thorpe et al. (2012).

There are several melodic features that could contribute to the descriptive analysis, therefore features deemed to be representative of schematic, within-group, and veridical expectations will be explored at two levels of perceptual complexity: low level which describes sensory and concrete information (such as contour, adjacent pitches, chunks of notes) and high level which is involves the formation and abstraction of groups and concepts (pertaining to sequences of three or more pitches, phrase boundaries, tonal structure). Table 2.2 presents the melodic features that are of interest and are discussed below. Figure 2.1 presents the way in which the melodic features relate to the stimulus.

Table 2.2. Melodic features that are relevant to the descriptive analysis, categorised by source of expectation and perceptual complexity.

Melodic feature	Expectation	Perceptual complexity
Contour	Sensory	Low level
Pitch adjacency	Schematic	Low level
Pitch range	Schematic	Low level
Pattern repetition	Veridical	High level
Pattern continuation	Within-group	High level
Scale degree	Schematic	High level
Phrase boundaries	Schematic	High level

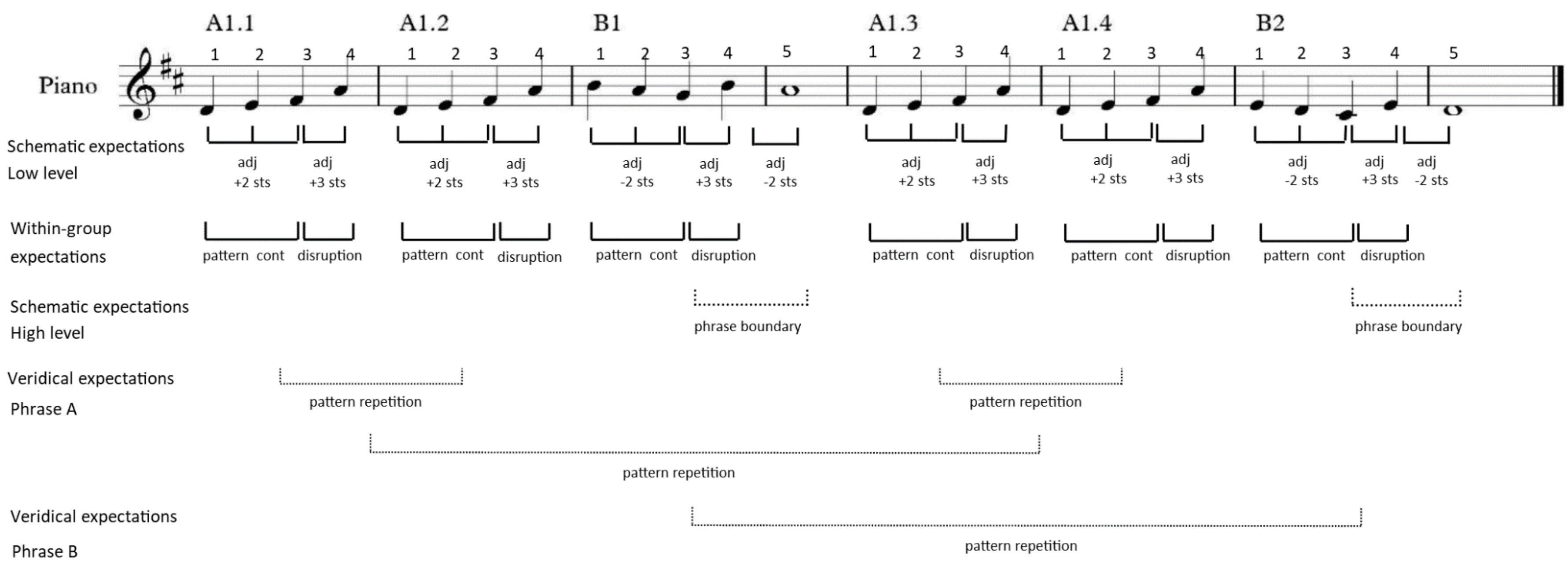


Figure 2.1. Diagram showing how melodic features appear in the experimental stimulus.

adj = adjacency. **+2 sts** = a 2-semitone interval. **+3 sts** = a 3-semitone interval. **pattern cont** = pattern continuation. d**isruption** = Pattern disruption.

2.5.1.2 Hypotheses specific to stimulus construction

Here, *contour* considers the current study's potential methodological limitations whereby the process of generating pitch-by-pitch expectancy ratings may instead lead the participants to follow the melody's contour (Trower, 2011). This therefore refers to a low level sensory influence that may only affect children who are very young, or who have ASC.

Pitch adjacency refers to the zygonic model's principle of 'adjacency' whereby the strength of implication will decrease as the distance between pitches increases (Thorpe et al., 2012). This is an adaption of the schematic principle of pitch proximity (Anta, 2013; Huron, 2006; Narmour, 1990; Ockelford, 2006; Schellenberg 1997; Thorpe et al., 2012) which describes the expectation for pitches to be proximate. Hence, in the present stimulus, it is predicted that smaller intervals will be more expected than larger intervals. For example, the major 2^{nd} in phrase A (pitches 1-2 and 2-3) will be more expected than the major 3^{rd} in phrase A (pitches 3-4), and the major 2^{nd} in phrase B (pitches 1-2 and 2-3) would be more expected than the major 3^{rd} (pitches 3-4).

Pitch range refers to the notion that mid-range pitches occur more frequently than pitches at the extremes (Thorpe et al. 2012), that listeners expect melodies to occur within a narrow range (Temperley, 2008). It also acknowledges a statistical principle called regression to the mean, whereby most pitches occur near the centre of a melody's range (Huron, 2006; von Hippel and Huron, 2000), but to which listeners mistakenly attribute a heuristic known as post-skip reversal, a principle that refers to a schematically learned perceptual process occurring temporally within-groups. Evidence of a post-skip reversal heuristic rather than regression to the mean (Huron, 2006) generates the hypothesis that the range of the current stimulus (within 1 octave) would not influence expectations.

Pattern repetition relates to veridical expectations occurring within and between pieces of music (Huron, 2006; Ockelford, 2006; Thorpe et al., 2012). Listeners may exhibit veridical expectations for phrase repetition and stimulus repetition, and the impact of this may alter between the two experimental sessions. In the current study, it is predicted that listeners will exhibit between-group veridical expectations for phrase A repetition, and the veridical expectation will 'kick in' more rapidly with each re-presentation of phrase A within each trial. On the other hand, veridical expectations for the transposed phrase B will take longer to 'kick in' with each re-presentation. Furthermore, as hypothesised, the veridical influence will decline during the week between each experimental session but will reinstate more rapidly during the second session. This will occur at a quicker rate for phrase A than for phrase B.

Pattern continuation is representative of within-group expectation, as identified by Thorpe et al. (2012). This is deemed to be a low-order Gestalt-based schematic process (Narmour, 1991), but it can also refer to sequences of notes that may include changes of melodic direction, therefore it is categorised here as high level. With reference to the current stimulus, within-group expectations that offer a secondary source of general implication are implied by the ascending scale in phrase A. For example, pitches 1-2-3 in phrase A establish an ascending pattern of 2-semitone intervals, which is then disrupted by a 3-semitone interval at pitch 4. Similarly, in phrase B1, pitches 1-2-3 establish a descending pattern of 2-semitone intervals which is disrupted by a 3-semitone interval at pitch 4.

Scale degree relates to the position of a pitch along a scale, relative to the tonic. Some scale degrees – such as those in the tonic triad, occur more frequently than others – such as chromatic tones – and therefore will be more or less probable than others (Aarden, 2003; Huron, 2006). This is a learned schematic expectation that also relates to structural properties of melody such as phrase boundaries and structural transitions. In the current study, schematic expectations that offer a primary source of general implication will be based on the sense of tonality set up by phrases A and B. For example, the scale degrees that comprise phrase A are i-ii-iii-v in the key of D, which, according to the work of Aarden (2003), comprises the three most commonly occurring scale degrees, and thus implies a tonal context of D major to the listener through the projection of schematic expectations.

Phrase boundaries influence expectations depending on temporal location whereby specific scale degree patterns generate expectations for a phrase ending. For example, in the present study, the imperfect cadence from pitches 4-5 in phrase B1 and the plagal cadence from pitches 4-5 in B2 both represent phrase endings which have a high probability of occurrence within a given tonal context (Aarden, 2003; Eerola 2003; Huron, 2006).

Each of these features contribute to the analysis across all participant groups. Furthermore, it is expected that each phrase's idiosyncrasies will give rise to different sets of expectations. For example, phrase A is repeated twice as often as phrase B, thus veridical expectations for phrase A will be heightened, and phrase B's transposed repetition will highlight more sophisticated cognitive processes that may only emerge in older children. Analysis of two separate phrases should illustrate how these different melodic patterns are perceived and cognised both as distinct units and as part of a larger whole. Moreover, as conjectured in Thorpe et al. (2012), general expectations will dominate during the first hearing of the stimulus, and will become less dominant after successive repetitions whereby specific expectations will come to the forefront, and the greatest difference between trials would exist between the first trial and other trials, or in other words, between what's novel, and what's been heard before.

It should also be noted that distinguishing between schematic and within-group expectations can be problematic as the current stimulus is constructed of repeating patterns that naturally combine various melodic principles. However, there are various points in the melody at which it is possible to deduce the root of the expectation. For example, schematic expectations can be generated from as little as two successive pitches, whereas within-group expectations are generated from a sequence of three or more pitches that imply a pattern. Therefore, it is easier to deduce whether participants' responses are underpinned by within-group expectations, but less easy to determine the responses that are not underpinned by schematic expectations. As some schematic expectations represent global melodic features such as phrase boundaries and tonal stability, these are observable at phrase boundaries in the melody.

2.5.1.3 Practice melody and distractors

A B

Figure 2.2. *A*: The practice melody, presented to participants prior to starting the experiment. *B:* An example of a distractor melody, which was presented to participants between repetitions of the melodic stimulus.

A shorter practice melody (Figure 2.2 A) was devised according to the criteria detailed above. The main purpose of the practice melody was to acquaint participants with the rating equipment and the task requirements. This also gave the experimenter an opportunity to assess the participant's understanding of the task. The stimulus tempo was set at 40bpm, which was found to be slow enough to give time for participants to respond yet does not appear to affect the melodic 'narrative' (Trower, 2011). Additionally, nine distractor sequences comprising eight random pitches centred around one octave, presented at 100bpm in the same timbre as the stimulus were composed (see Figure 2.2 B for an example). A randomised distractor was positioned between each stimulus presentation to minimise rehearsal effects, which could produce unwanted ceiling effects. Randomisation was achieved by allocating a number to each distractor and using an online random number generator. Diana Deutsch (1999) reports that a series of random interpolated tones presented as the same sound as the target stimuli are an effective distractor over a short period.

2.5.1.3 Presentation of audio materials

The stimulus, practice, and distractor materials were created using the notation software, Sibelius, and were exported as a Steinway piano sound using Logic. The stimulus lasts for 48 seconds (crotchets are 1.5 seconds, and semibreves are 6 seconds), and is presented four times. Each distractor lasts for 5.5 seconds and is inserted into a 10 second gap between each stimulus repetition. The overall experiment lasts for 3 minutes 50 seconds. Considering that some participants may have difficulties staying focused for prolonged periods of time, a short timeframe is advantageous and complements the decision to use the continuous response method since it is less time-consuming than other available methods. As this is a controlled experiment, ecological validity is inevitably compromised in that participants are listening to artificially constructed music and responding using an unfamiliar rating task. The measurement of expectations presents challenges due to their non-conscious nature, so even though artificially constructed stimulus materials are unlikely to be encountered in a natural music listening environment, the use of alternative stimulus materials such as entire musical pieces or extracts from existing pieces would increase the number of confounding variables, making it difficult to achieve the current research objectives.

2.5.2. Questionnaire materials

The musical experiences of different people may influence their responses in the experimental task, so each participant was asked to complete a short questionnaire (see

Appendix F and G) comprising four sections totalling two sides of A4 paper, namely; demographics, playing an instrument, music listening, and reflection. The first section was identical for children (TD and ASC) and adults, requesting gender, date of birth and nationality. As discussed in section 2.4, gender and age are key independent variables. Additionally, participants' nationality may give an indication about their musical background, and this is followed up with a later question about music listening preferences. The second section asked questions about formal and informal experiences with playing an instrument. Children were asked about instrumental tuition at school outside of the curriculum, and instrumental tuition outside of school, whereas adults were asked about instrumental tuition (either in or out of school), and whether they have ever taught themselves an instrument. At the time of devising the questionnaire, it was assumed that most children would not be teaching themselves an instrument, although in hindsight this should have been included, as during data collection some older children mentioned that they played a self-taught instrument. In the third section, participants were asked how much time they spend listening to music of their own choice, and to give as much detail as possible about music listening preferences. These questions were asked so that any potential impact of musical exposure on the dependent variable could be monitored. For example, extensive exposure to musical idioms other than Western music may affect tonality and interval perception. In section 4, participants rated on a Likert scale about the experiment's difficulty and enjoyability. Any issues arising within the data may be linked to perceived difficulty or likeability. Space was provided for further comments.

2.6 Apparatus

Historically, the continuous response method was executed using a Continuous Response Digital Interface (CRDI) which allows users to move a dial 180 degrees from left to right, however, this method requires users to jump to different locations, potentially affecting speed and accuracy of response. Alternatively, a modified version known as the

Continuous Response Measurement Apparatus (CReMA), first developed by Evangelos Himonides (2011), offers enhanced speed and accuracy due to its linear composition. Users can respond by moving their forefinger along a touch-sensitive ribbon placed on a desk in front of them. The data from each finger-touch is sent via MIDI to a connected computer, meaning that real-time data can be collated during music listening. The CReMA is replicable in that a range of participant groups with various physical and intellectual abilities may be able to utilise it. There is also scope for many forms of stimuli to be tested, such as rhythmic, verbal, and visual. The specific MIDI instrument used in this experiment is known as a *Vmeter* MIDI touch strip, purchased from http://www.vmeter.net/.

In the current experiment, the touch strip represents a bipolar scale, ranging from ‘very unexpected’ on the left, to ‘very expected’ on the right. Additional visual support such as labelling or smiley faces was thought to be too distracting, for example, sad and smiley faces may confuse participants into rating ‘goodness of fit’ or ‘liking’ for the stimulus, rather than ‘expectedness’. However, occasionally, younger participants found it difficult to remember which end of the scale was which, so in this case, a smiley face indicator was located at each end of the scale despite a preference not use them generally. In most cases, the *Vmeter*’s blue LEDs were useful for tracking participants’ responses. A handful of participants were distracted by the lights, playfully running their finger up and down the touch strip, so in these instances the lights were covered with a sheet of paper.

2.7 Procedure

I conducted the experiments in a quiet room either at school, university or the participant’s home. Each participant took part in two experimental sessions separated by one week, each lasting around 15 minutes. During each session, participants heard the melody four times. Here, each melody presentation is referred to as a trial. Thus, listeners took part in four trials during each session, totalling eight trials altogether. It was important to conduct the research over two sessions so that short-term and long-term memory systems were activated. It is reported that listeners consciously regulate their exposure to pieces of music, avoiding over-listening by 'resting' a piece before resuming regular listening. This implies that repetition of musical pieces may have a cumulative effect on memory which is renewed after an intermission. For example, Greasley and Lamont observe (2013) that "by avoiding excessive levels of exposure, the relationship between familiarity/complexity and liking can proceed in a pattern of waxing and waning". Further, in her book, *On Repeat*, Margulis comments that listening repeatedly to the same piece results in a "steady and unconscious improvement in musical orientation" (2014, p. 106). Despite this anecdotal knowledge, this is the first study to observe expectations in response to repeated exposures of the same musical stimulus on more than one occasion, therefore, the choice to separate the sessions by one week was exploratory, and based on logistics and time constraints relating to participant recruitment, rather than based on theoretical conjecture. For example, a lengthy period between sessions may result in participant absence and the forgetting of task instructions, and the same day each week may be easier for participants and/or care givers to remember and fit in to their schedules.

During the instruction stage at the beginning of each session, participants were told that they would hear four melodies. This was to counteract any prior assumption that the stimulus is repeated, as this could lead to ratings being dominated by veridical expectations, potentially resulting in a lack of observable schematic or within-group expectations. Following the instruction stage, participants were presented with the practice melody which gave them an opportunity to acquaint themselves with the rating tool and to ask questions. Thereafter, the stimulus melody was played through headphones four times during each session, totalling eight stimulus repetitions altogether. Using the MIDI touch strip, participants rated their perceived expectedness in response to each note of each stimulus presentation whilst ignoring the distractors. Once the rating task was complete during the first session, participants completed the questionnaire. Some children required additional support at the beginning of each session whereby the concept of expectedness was explained in more detail. Children were asked questions such as "if you were at the park, would you expect to see a slide/dog/giraffe?" and "would you expect to have toast/pizza/a blue banana for breakfast?". Picture cards were shown relating to the question, and children were asked to respond using the rating scale. See Figure 2.3 for an example of the images used.

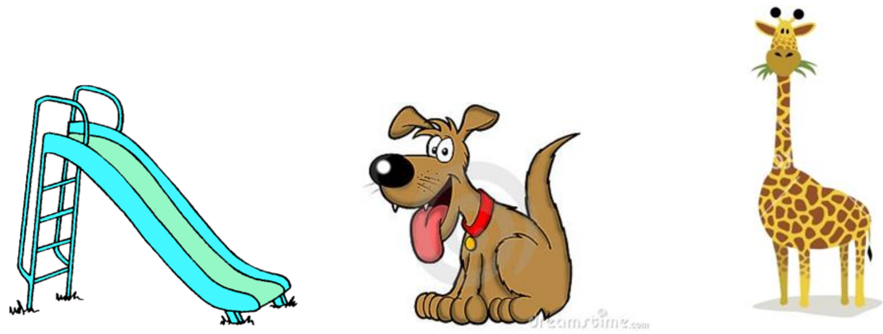


Figure 2.3. Examples of the picture cards presented to children during task instructions.

Children who answered correctly, would rate 'very expected' for the slide, 'very unexpected' for the giraffe, and somewhere between the two for the dog. Children who failed to complete this task correctly were not included in the experiment. Children who responded correctly were then given a second pre-experiment task that applied the rating process to music. Different versions of a rising and descending scale were sung by the experimenter, and children were asked to rate how expected or unexpected the *last* note was. This was the final way of gauging whether children had understood the task requirements prior to commencing the experiment. Occasionally, the words 'surprising' and 'not surprising' facilitated a better understanding.

Each experiment was intended to be carried out in the same way so as not to impact inadvertently on participants' responses. The instructions were always provided orally, and followed the same format: Each participant was told that the MIDI touch strip is a scale that ranges from ‘very unexpected’ on the left, to ‘very expected’ on the right. They should begin at the centre of the strip prior to the start of each new melody. They were asked to refrain from sliding their finger across the strip as this gives numerous responses, rather they should tap once for each note, even if the response is the same. Participants were also told that there is no right or wrong answer, and if they make a mistake, not to dwell and to move on to the next pitch. Instructions were not always followed despite careful preparation. For example, some participants only moved their finger when there was a change in the rating – this was noted down by the experimenter to assist during the data analysis stage. Others preferred to slide their finger and had to be prompted to instead provide a tap for each response – dealing with numerous responses will be addressed in the data interpretation section of this chapter. There were some issues with younger children whose smaller fingers were not registered by the touch strip. In this case, children were prompted to use the flat of their finger. Written notes about unrecorded responses were logged by the experimenter.

Despite careful consideration of the methods used in this study, there are some limitations that were difficult to avoid. Firstly, as there was a week’s gap in between the two sessions, some participants were absent for the second session. This was particularly common in the adult participant group due to them being recruited as individuals rather than attending a specific location. A second limitation relates to the terms ‘expected’ and ‘unexpected’, in that some younger children had difficulty comprehending. In some cases, the terminology was changed to ‘surprising’ and ‘unsurprising’. These terms were preferred when compared with other alternatives such as ‘like’ and dislike’ or sounds ‘good’ and bad’. A third issue concerns the wide range in participants’ age and musical ability. Designing a study that allowed for these differences was challenging, although the additional preparation with the youngest children was deemed successful. In summary, the procedure involved participation in 2 x 15-minute sessions, separated by one week whereby participants gave note-by-note expectancy ratings to four repetitions of the same stimulus in each session, totalling eight repetitions altogether, resulting in 200 expectancy ratings per participant. The following section outlines the methods used for analysis.

2.8 Data analysis

Upon completion of experiments, data were converted from a MIDI file into a CSV file for use in spreadsheet format, using software developed by Himonides, known as CReMA MIDI, which can be downloaded from http://www.imerc.org/crema. Data from each participant were saved as an individual file, which is accessible using Microsoft Excel. The CSV file displays columns pertaining to a) a MIDI response value between 0 and 127 that represents the expectancy rating (0 = ‘very unexpected’ and 127 = ‘very expected’); b) time of response measured in ticks (the amount of time passed since the last heard pitch event was presented); and c) cumulative time of response measured in ticks (the amount of time passed since the first pitch event was presented). Ticks are a tempo-dependent measurement of musical time in MIDI, where each beat = 960 ticks. Ticks were converted into seconds for analysis.

The allocation of expectancy responses to pitch events accorded with specific criteria to be discussed in the following section. Expectations pertaining to pitch relationships are the focus, hence analysis concentrated on pitches 2 to 26, discarding the first pitch. Over the two sessions there are 200 analysable responses for 200 pitch events per participant. A latency response threshold was set at 0.4 seconds, as indicated by Laming (1968), who suggested that simple reaction times (for one stimulus and one response) are approximately 0.2 seconds, and recognition reaction times (a choice of responses) are no quicker than 0.4 seconds. In a listen and play experiment whereby the autistic savant, Derek Paravicini was to replicate a novel piece of music, Ockelford and Grundy (2014) calculated that Derek’s quickest reaction time was 0.4 seconds. This was confirmed by observing the response times provided by a sample of ten adults from the current study. The average and quickest response times for each trial were calculated, and the data showed that the quickest response was 0.4 seconds, and the average response time was 1 second. The average response time for pitches 13 and 26 were slightly quicker at 0.8 seconds. Therefore, the interpretation criteria were as follows:

a) Minimum response time: 0.4 seconds. This is the quickest reaction time according to the above discussion.
b) Maximum response time: 2 seconds. The maximum response time threshold was set at 2s (the duration of 1.5 pitch events). Other studies report that adult participants have taken as long as 1.2 seconds to perform consonant/dissonant judgements in response to primed chord sequences (Bigand, Poulin, Tillmann, Madurell, & D'Adamo, 2003; Bigand, Tillmann, Poulin-Charronnat, & Manderlier, 2005), so 2 seconds allows for a wider choice of responses, and the possibility of slower response times made by children.
c) Missing values were left blank unless it was made explicit by the participant that an expectancy rating was intended to be carried over to multiple pitch events. These occasions were noted by the experimenter.
d) In some cases, where the participant slid instead of tapped their finger on the MIDI controller (generating multiple responses), the response which was provided at 0.4 seconds was allocated.
e) If it was unclear as to which pitch a response relates, then it was regarded as a missing value and not included in analysis.

In order to observe how pattern perception develops in response to repetition in different age groups, analysis was conducted using a combination of quantitative and descriptive methods, applied in four stages. First, quantitative methods provided statistically robust means of addressing the research questions by measuring the influence of stimulus repetition on within trials (phrase level) and between trials (whole melody level), and to detect potential changes between participant groups. Specifically, a repeated measures ANOVA was selected because it detects differences between mean scores at multiple connected time points and can incorporate more than one test group and is therefore suitable for observing veridical expectations that occur within each trial and between each trial. Within each participant group, separate ANOVAs were performed to compare means between sessions (x2) and between trials (x8). Thereafter, an ANOVA was also conducted between groups (x5) to compare means between sessions (x2) and trials (x8). Furthermore, where heteroscedasticity assumptions were not met, Greenhouse Geisser corrections are reported for all experiments.

Second, descriptive methods can also be useful for exploring behavioural data in situations when the research topic is in its early stages – such as the influence of within-group and schematic expectations in children with and without autism in the context of repetition – and for observing perceptual changes that are not detectable through quantitative means. For example, as noted in the hypothesis section, differences between within-group and schematic expectations may not be visible from a quantitative analysis perspective as some of their features overlap, and so a descriptive approach may address that aspect as the melody undergoes an evolving and dynamic narrative. Thus, examining data using informed interpretation can complement the quantitative findings and provide a basis upon which hypothesis-driven statistical methods can follow.

Third, to support the descriptive analysis, measuring the variance in participants' ratings can serve as a proxy for reliability and consistency. Time series analysis (using MPlus) was selected as a suitable method for examining how the relationship between successive pitches alters over time. Time series analysis produces an autocorrelation coefficient (ø), and a mean value (intercept) for each set of ratings. The coefficient can be used as a marker for how much variance is present in the rating contour, and the intercept provides an overview of the mean which is also indicative of the presence of veridical expectations. This is a useful tool for comparing differences in how expectations interact between participant groups for temporal stimuli such as music.

Fourth, the influence of additional variables on participants' ratings can be assessed using multiple linear regression, which predicts whether a dependent variable changes in the presence of an independent variable. In this instance, the influence of age, weekly minutes of music listening, and months of musical training on expectancy ratings were assessed.

2.9 Ethical considerations

All reported experiments were submitted to the University of Roehampton's Ethics Committee, and ethical approval was granted on the 4th March 2014. All participant data were kept in the author's home office and on a password protected personal desktop computer. Anonymity was ensured by allocating each participant with a participant number and destroying any paperwork that contained names. Consent forms (see Appendix E) were kept locked in an office drawer along with paper copies of the questionnaire data, to be stored for approximately ten years. Prior to the experiment and prior to obtaining consent, all participants were fully disclosed as to the aims and objectives of the study. The caregiver of TD children and autistic children gave consent on their behalf, and this was usually collected by the participating school or college. All participants were given the right to withdraw without detriment even after having agreed to take part. Anonymous demographic information may be disseminated in the thesis write-up and future publications, only where directly relevant. In the event of sharing data with directly involved researchers (such as the PhD supervisors), this will be shared via a secure password protected cloud website such as www.dropbox.com thus avoiding distribution of hardcopies. All data will be handled in accordance with the Data Protection Act 1998, and Roehampton's Ethical Guidelines for Research Practice and Teaching.

A requirement of working with children is to have an enhanced criminal records check (DBS), and this was kept up-to-date using the DBS online service. It was possible that some children would find the experiment daunting or confusing and potentially stressful. Hence embodying a friendly and approachable manner, encouraging conversation about the school day, and allowing plenty of time for practice runs prior to the core experiment was important. It was anticipated that some of the pre-experiment questions would help some children to relax thereby reducing any possible emotional impact of the study. The social and emotional vulnerabilities exhibited by children with autism were recognised and accounted for by providing extra time for instructions and practice runs, and maintaining an awareness of possible difficulties with task comprehension. Often, an adult known to the autistic participant would supervise during the experiment and this would enhance the child's comfort.

In accordance with the University of Roehampton's Lone Working Policy, supervisors were kept up-to-date with the whereabouts of experimental locations, which were usually in schools, colleges or universities. Occasional visits were made to participants' homes during working hours, and this was always communicated to a friend or family member. The researcher was always contactable by mobile phone. Experiments that involved autistic children were usually accompanied by a teaching assistant from the participating school. Fire and safeguarding procedures were obtained at the beginning of each visit to a new participating institution.

2.10 Chapter summary

This chapter introduced various quantitative methods used for measuring melodic expectations, and confirmed that a repeated measures design within a continuous response paradigm was appropriate for this study's research objectives. The motives for selecting typically developing adults and children, and autistic children were explained, as was the recruitment procedure, including challenges that arose during recruitment. The experimental materials, apparatus, and procedure were considered with reference to each participant group. Methods for data analysis were explained, whereby criteria were set based on an examination of literature, and finally, ethical considerations were put forward with reference to each participant group.

3 Results: typically developing adults

This chapter reports the results from the first of three experiments, which investigates the melodic expectations of adult listeners familiar with Western music. Forty-three participants took part in two experimental sessions, separated by one week (see Figure 3.1). During each session, participants were presented with the melodic stimulus four times, totalling eight stimulus presentations over the two sessions. Each stimulus presentation is referred to as a trial. During each trial, participants rated their perceived expectedness for each note except for the first, resulting in 25 expectancy ratings per trial per participant, and totalling 200 expectancy ratings per participant across both sessions. To reinstate, each session consists of four trials. Each trial consists of four appearances of phrase A, and two appearances of phrase B. Analysis will focus on comparisons between sessions 1 and 2, between trials 1-8, and between phrase A and phrase B.

Experiment 1's research objective is to gather empirical evidence to investigate the changing interplay between within- and between-group expectations encoded schematically and veridically, as conjectured by Huron (2006) and Thorpe et al., (2012). This chapter refers to research question 1, with a focus on typical adults: Does melodic repetition influence the relationship between schematic, veridical and within-group expectations cumulatively in 'typical' adults?

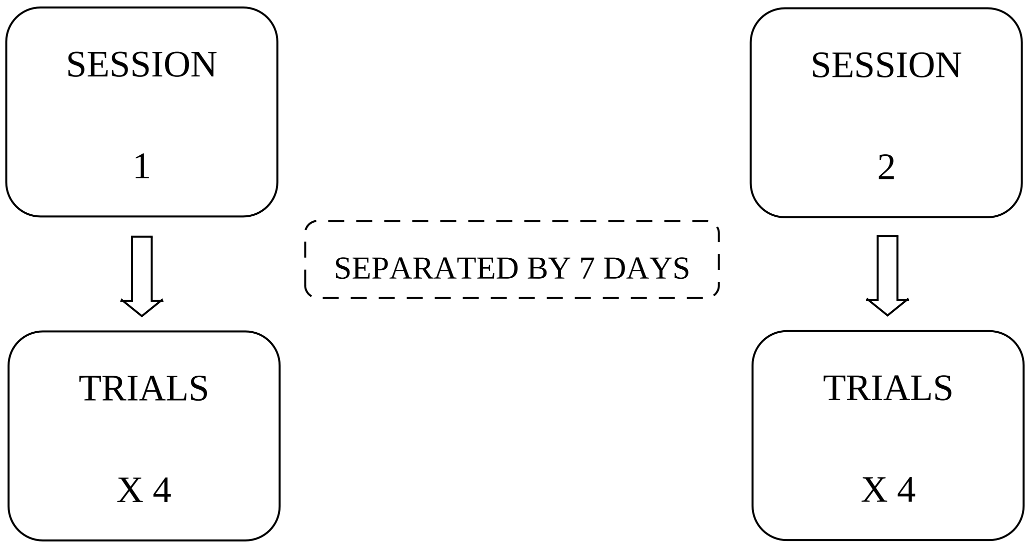


Figure 3.1. Visual representation of the experimental procedure.

Ockelford's zygonic theory is selected as the core analytical framework for the present thesis (Ockelford, 2006, 2012, 2017), because it presents a clear theoretical basis for addressing the paradox of why listeners can be 'surprised' during familiar music listening. Previous models of musical understanding have not addressed this puzzle with the same interest (refer to the literature review, chapter 1, for a review). The zygonic model also offers precise means of examining the research question elements outlined in the above paragraph. Findings will also be discussed in light of the melodic features set out in Table 2.2 in the methods chapter. Next, descriptive statistics are presented in section 3.1, followed by an analysis of expectancy ratings at the session and trial level (section 3.2) and analysis of expectancy ratings at the pitch level (section 3.3). Thereafter, results from the questionnaire are presented in section 3.4 followed by an extended summary in section 3.5.

3.1 Participants

Forty-three adult participants with an age range spanning five decades (27 males; mean age = 33; *SD* = 12.6) took part in the study. Some participants dropped out after the first session. Table 3.1 recaps the number of adult males and females taking part in each session.

Table 3.1. Number of adult participants in session 1 and session 2.

Gender	**Session 1**	**Session 2**
Male	27	21
Female	16	13
Total	43	34

Fourteen males and zero females were recruited from a Popular Music and Recording undergraduate degree at the University of Salford. The unequal gender balance recruited from this location was unforeseen due to miscommunication. The remaining participants were recruited through word of mouth, none of whom were attending advanced music education. Collectively, males have more instrument playing experience than females as shown below in Figures 3.2 and 3.3. Participants' musical backgrounds were varied, ranging from 0-24 years of private instrumental tuition (mean = 4.17 years), and 0-25 years playing a self-taught instrument (mean = 4.7 years). Thirty-three participants had received private instrumental tuition, the majority of whom played guitar (29%), piano (22%) and woodwind (19%). The remainder were trained on percussion, horn, saxophone, and voice. Twenty-five participants played a self-taught instrument, most of whom played guitar (23%). Participants had also taught themselves to play piano, drums, ukulele, mandolin, bass guitar, saxophone, clarinet, and trumpet. Forty participants were British, one Canadian, one Italian, and one Hungarian. All participants were familiar with Western music. Of the 39 participants who listened to music, 60% reported listening to less than 10 hours of music per week, 20% reported listening to music for between 10 and 20 hours per week, and 20% reported listening to music for between 21 and 70 hours per week. As depicted in Figure 3.2 and 3.3, more males than females underwent private instrumental tuition, and more males than females reported playing a self-taught instrument.

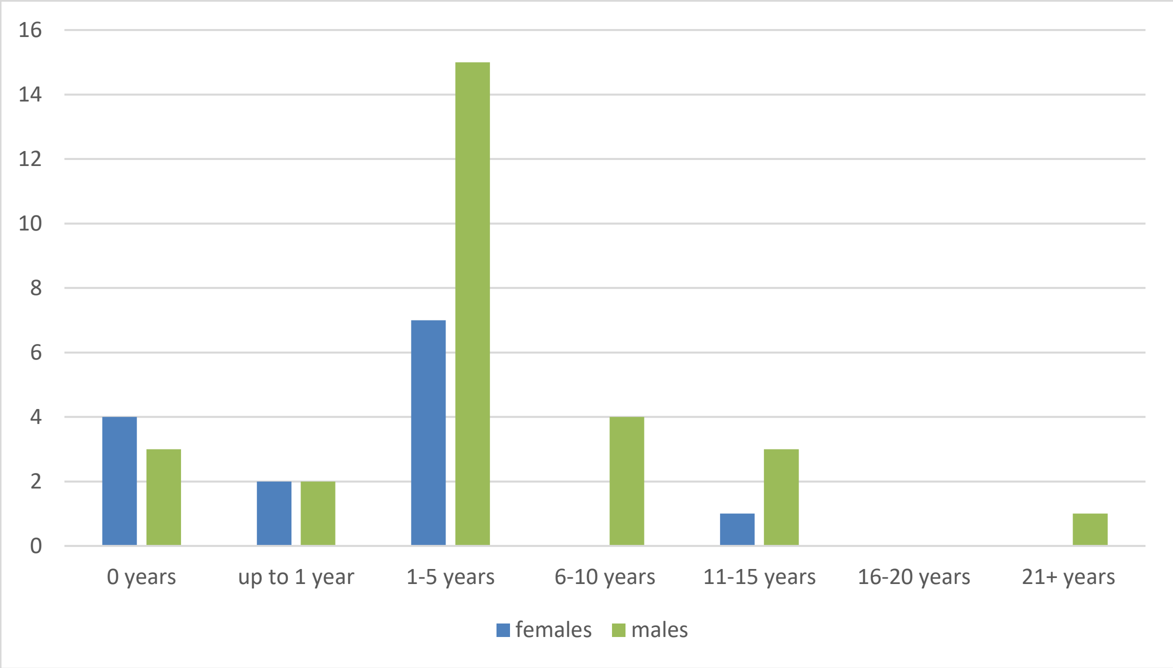


Figure 3.2. Adult males’ and females’ years of private instrumental tuition.

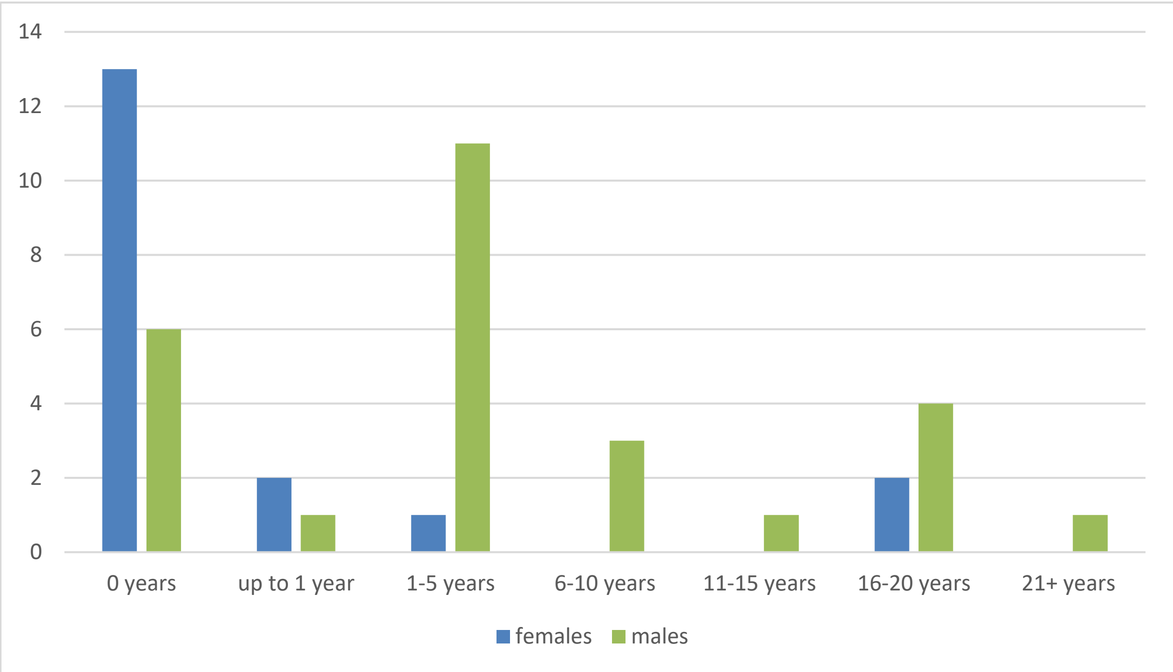


Figure 3.3. Adult males’ and females’ years playing a self-taught instrument.

3.2 Session and trial level analysis (quantitative)

The following section presents a series of repeated measures ANOVAs, contextualised by the stimulus as a whole (see section 3.2.1), phrase A (see section 3.2.2) and phrase B (see section 3.2.3). Prior to conducting ANOVAs, the data were aggregated into mean scores for session and trial, and checked for normality. Results from the normality tests can be seen in Appendix A.3.2.1 Whole melody

Initial overall results displayed in Figure 3.4 show that expectancy ratings were higher in session 2 compared with session 1. Mean expectancy ratings for each trial are displayed on the x-axis. A one-way repeated measures ANOVA comparing the two sessions confirms that this difference is significant, and the effect size is moderate (Field, 2017) $F(1, 33) = 19.570$, $p = .000$, partial $\eta^2 = .372$. A second ANOVA compared all eight trials, and revealed a significant effect of trial on mean expectancy ratings with a moderate effect size $F(3.642, 120.184) = 17.192$, $p = .000$, partial $\eta^2 = .343$.

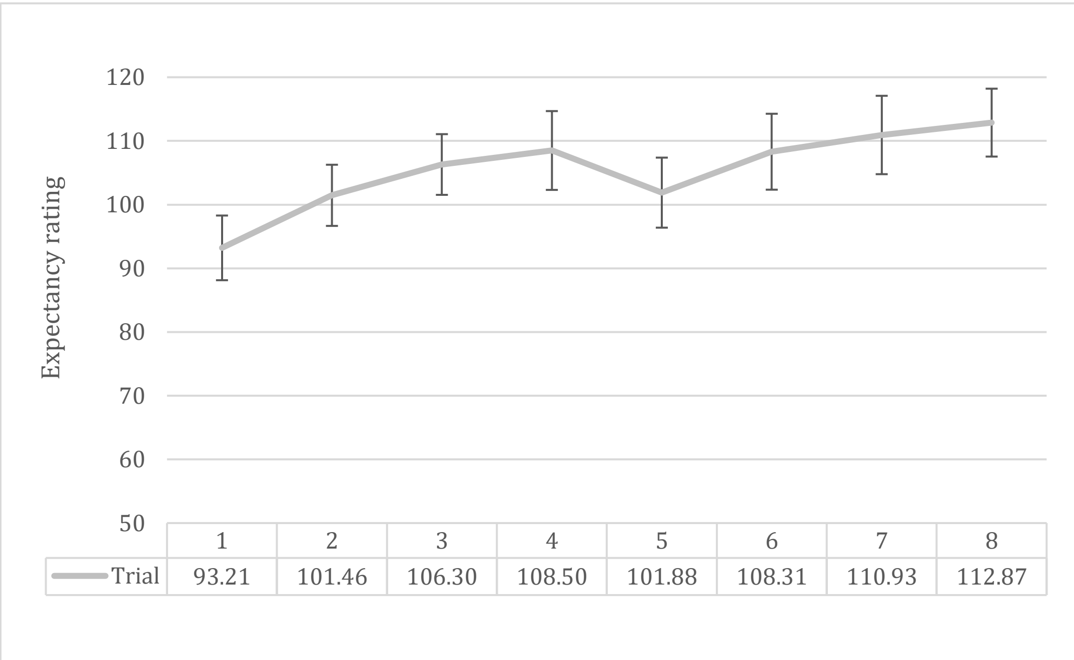


Figure 3.4. Whole melody. Adults' mean expectancy ratings for trials 1-8.

Table 3.5. Whole melody. Adults' repeated measures ANOVA contrasts for trials 1-8.

Session	Trial	F	*p* value	Partial eta squared
Session 1	1-2	19.379	0.000***	0.37
	2-3	9.527	0.025*	0.219
	3-4	0.922	0.344	0.027
	4-5	7.076	0.048*	0.177
Session 2	5-6	11.216	0.012*	0.254
	6-7	3.055	0.18	0.085
	7-8	4.264	0.141	0.114

*p < .05. **p < .01. ***p < .001.

Post-hoc comparisons (Table 3.5) reveal a significant increase in expectedness between trials 1-2 and 2-3, and a significant decrease in expectedness during the 7-day gap between sessions 1 and 2 (trials 4-5). During session two, trials 5-6 also show a significant increase in expectedness. In relation to the research question, this tentatively suggests that stimulus repetition influences participants' ratings, which is affected by recency of the stimulus presentation, whereby expectations are 'reset' during periods of rest. This overall trend serves as the motivation for more directed analysis whereby – as discussed in the materials section in the methods chapter (see section 2.5.1) – schematic, within-group and veridical expectations are set up through the inclusion of phrases A and B. Considering the hypothesis that expectations may develop at a different rate for phrases A and B, two separate repeated measures ANOVAs were performed, firstly with expectancy ratings for phrase A as the independent variable (in section 3.2.2), and secondly, with expectancy ratings for phrase B (section 3.2.3) as the independent variable.

3.1.2 Phrase A

This section reports results from a repeated measures ANOVA comparing eight trials, considering only the pitches that comprise phrase A. A significant effect of trial on expectancy ratings is revealed for phrase A $F(3.882, 128.107) = 14.463$, $p = .000$, partial

$\eta^2 = .305$. Mean scores and post-hoc results are presented in Figure 3.5 and Table 3.6, demonstrating a linear cumulative effect of repetition whereby expectedness increases throughout session 1, is dissipated during the 7-day interim, and is quickly reintroduced in session 2. Specifically, a significant increase occurs between trials 1-2, and 5-6. As hypothesised, and in accordance with zygonic conjecture, this suggests that veridical expectations become increasingly dominant throughout each session, but are momentarily dampened between sessions indicating an effect of melodic recency. After the 7-day gap during which expectedness decreases, trials 5-6 spark a significant increase in expectancy ratings, which are higher than those observed in session 1, indicating that the influence of repetition is more pronounced during the second session.

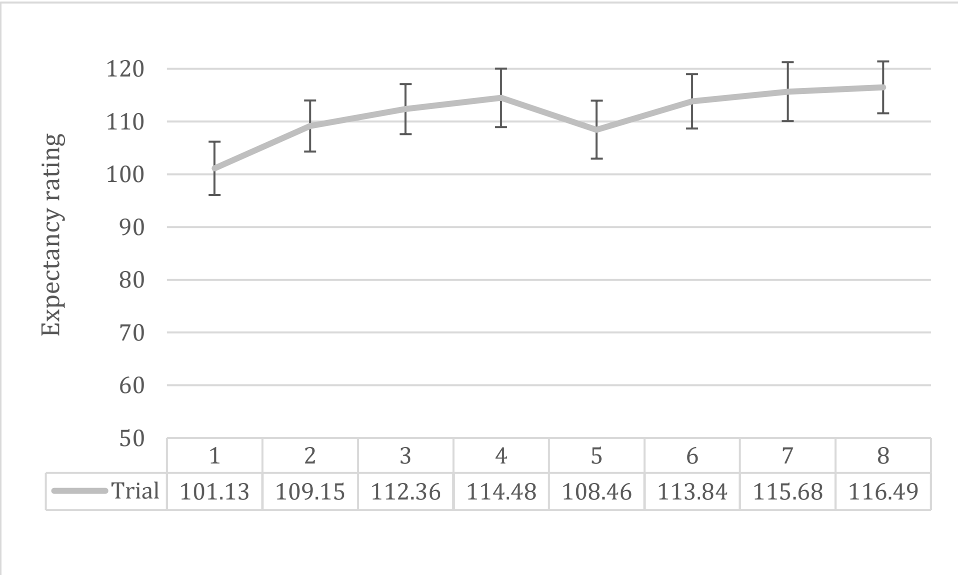


Figure 3.5. Phrase A. Adults' mean expectancy ratings for trials 1-8.

Table 3.6. Phrase A. Adults' repeated measures ANOVA contrasts for trials 1-8.

Session	Trial	F	*p* value	Partial eta squared
Session 1	1-2	18.469	0.000***	0.359
	2-3	4.624	0.156	0.123
	3-4	1.838	0.368	0.053
	4-5	7.115	0.06	0.177
Session 2	5-6	9.202	0.03*	0.218
	6-7	2.691	0.33	0.075
	7-8	0.701	0.409	0.021

*$p < .05$. **$p < .01$. ***$p < .001$.

3.1.3 Phrase B

A repeated measures ANOVA, considering only the pitches comprising phrase B was performed, revealing a significant effect of trial on expectations $F(3.308, 109.172) = 11.280$, $p = .000$, partial $\eta^2 = .255$. Mean scores and post-hoc results are presented in Figure 3.6 and Table 3.7. For the most part, the ratings for phrase B are similar to phrase A, in that there is a significant increase in expectedness between trials 1-2 and 5-6 and an overall trend for expectedness to increase throughout session 1, to dip between sessions and to continue increasing during session 2. Additionally, ratings for trials 2-3 are significant in response to phrase B, but not for phrase A.

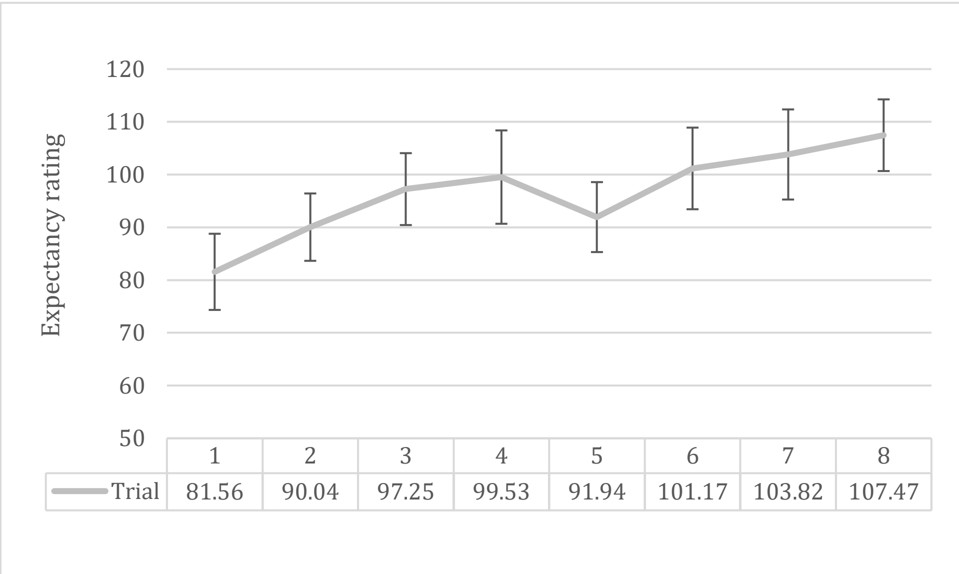


Figure 3.6. Phrase B. Adults' mean expectancy ratings for trials 1-8.

Table 3.7. Phrase B. Adults' repeated measures ANOVA contrasts for trials 1-8.

Session	Trial	F	*p* value	Partial eta squared
Session 1	1-2	7.918	0.040*	0.194
	2-3	9.469	0.024*	0.223
	3-4	0.089	0.768	0.003
Session 2	4-5	3.877	0.184	0.105
	5-6	11.243	0.014*	0.254
	6-7	0.907	0.696	0.027
	7-8	4.291	0.184	0.115

*$p < .05$. **$p < .01$. ***$p < .001$.

3.3 Pitch level analysis (descriptive)

So far in this chapter, it has been ascertained that veridical expectations are influenced by melodic repetition that is impacted by how recently the melody has been heard. Descriptive pitch-level analysis will enable more nuanced observations that focus on the emergence of pattern recognition, thus revealing participant responses that are generated from schematic and within-group expectations. As this section is descriptive, a focus on particular melodic features (as outlined in Table 2.2 of the methods chapter) is important for clarity and consistency.

Adults' pitch-by-pitch expectancy ratings for trials 1-8 are depicted in Figures 3.8 and 3.9 and Tables 3.9 and 3.10. The shaded sections on the figures represent the pitches that comprise phrase B, and the blue sections on the tables also refer to phrase B. Initial visual inspection reveals a trend that develops over time. Firstly, the pattern of expectation is almost identical for each trial, representing expectations that are deeply ingrained and weighted by probabilities of future events based on past trends. Secondly, as seen in the previous section (Figures 3.5 and 3.6), the overall expectedness increases with each trial, representing participants' veridical expectations which indicate mounting familiarity. A comparison of Figures 3.7 and 3.8 shows a visual depiction of the ANOVA results set out in Table 3.5, demonstrating how participants' veridical expectations are to some degree reset after a week rest, kicking in more rapidly in the second session, as evidenced by the higher expectancy scores provided at trial 6, compared with trial 2.

These summary data imply that there are different forms of expectation that change systematically in response to repetition of a musical piece or phrase. A sharper focus can tease out how groups of patterns spaced in pitch and time influence expectations in the context of relistening. This is achieved in the ensuing paragraphs which examine within- and between-group patterning, and melodic contour through the lens of zygonic theory, whilst also considering other principles of music perception that are present in similar analytical discourse (for example Huron, 2006; Narmour, 1990, 1991; Schellenberg, 1996), with reference to the melodic features set out in Table 2.2. For reference, the melodic stimulus is presented again in Figure 3.7.

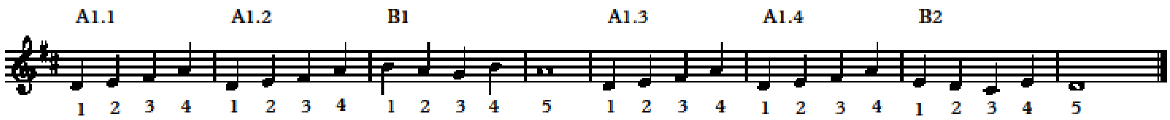


Figure 3.7. The experimental stimulus

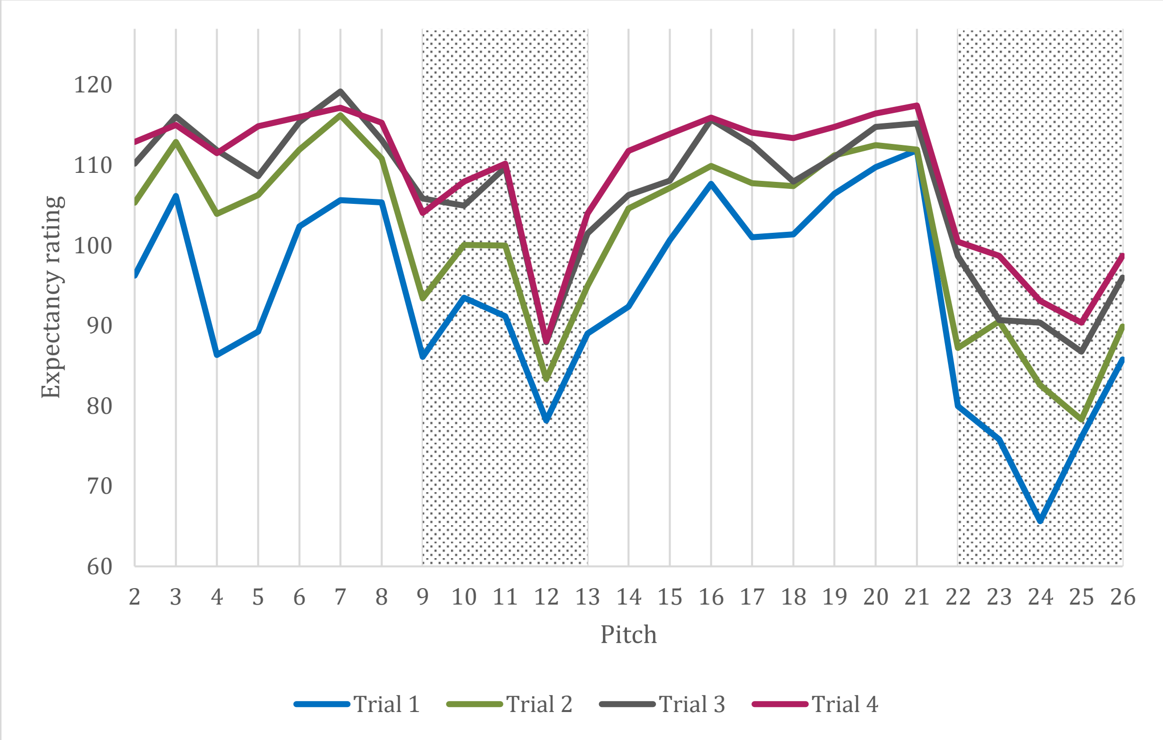


Figure 3.8. Adults' pitch-by-pitch expectancy ratings for trials 1-4 in session 1. Shaded sections signify phrase B.

Table 3.9. Adults' mean pitch-by-pitch expectancy ratings for trials 1-4 session 1.

Phrase	A1.1			A1.2				B1					A1.3				A1.4				B2				
Pitch	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Trial 1	96	106	86	89	102	106	105	86	93	91	78	89	92	101	108	101	101	106	110	112	80	76	66	76	86
Trial 2	105	113	104	106	112	116	111	93	100	100	83	95	105	107	110	108	107	111	113	112	87	91	83	78	90
Trial 3	110	116	112	109	115	119	113	106	105	110	88	101	106	108	116	113	108	111	115	115	99	91	90	87	96
Trial 4	113	115	111	115	116	117	115	104	108	110	88	104	112	114	116	114	113	115	116	117	100	99	93	90	99

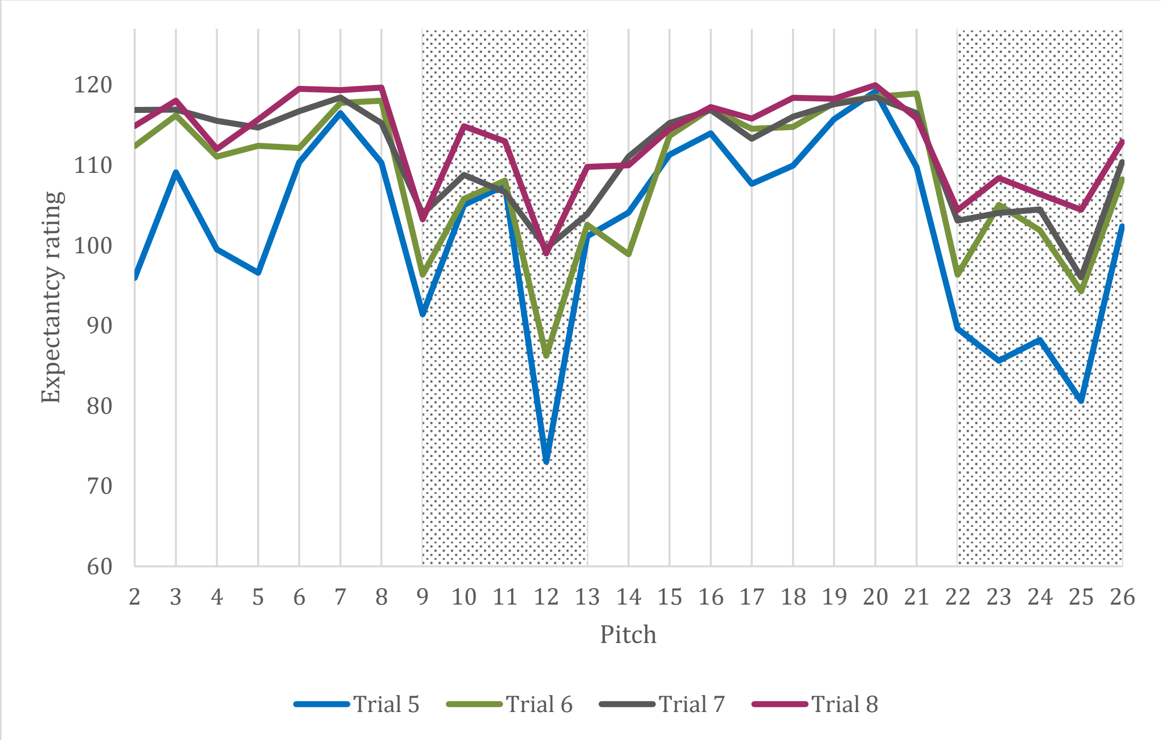


Figure 3.9. Adults' pitch-by-pitch expectancy ratings for trials 5-8 in session 2. Shaded sections signify phrase B.

Table 3.10. Adults' pitch-by-pitch expectancy ratings for trials 5-8 in session 2.

Phrase	A1.1			A1.2				B1					A1.3				A1.4				B2				
Pitch	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Trial 5	96	109	100	97	110	116	110	91	105	107	73	101	104	111	114	108	110	116	119	110	90	86	88	81	102
Trial 6	112	116	111	112	112	118	118	96	106	108	86	103	99	114	117	115	115	118	119	119	96	105	102	94	108
Trial 7	117	117	116	115	117	118	115	104	109	107	100	104	111	115	117	113	116	118	118	117	103	104	104	96	110
Trial 8	115	118	112	116	120	119	120	103	115	113	99	110	110	115	117	116	118	118	120	116	104	108	106	104	113

3.3.1 Phrase A first trial

The bullet points in the subsequent sections highlight consistencies and salient observations from the line graphs in Figures 3.8 and 3.9, above, followed by an interpretation framed by zygonic theory. First, phrase A in trial 1 is analysed.

- In phrase A1.1, an ascending major 2nd links pitches 1-2 and 2-3. This establishes a melodic pattern which generates an increase in participants' perceived expectedness. The pattern is disrupted by the major 3rd interval occurring between pitches 3-4 which is perceived as surprising by participants (see the 20-point decrease in expectedness between pitches 3-4 in trial 1, Table 3.9).

- The same major 3rd in the second presentation of phrase A (A1.2) is regarded as less surprising, whereby the expectancy rating decreases by 1 point (see A1.2 pitches 3-4 in trial 1, Table 3.9).
- After an interim during which phrase B is heard, phrase A is presented for the third time (A1.3). A similar trend occurs whereby the major 3rd in A1.3 is unexpected, albeit to a lesser degree than A1.1 (see the 7-point decrease between pitches 3-4, A1.3 in trial 1, Table 3.9).
- In contrast, the fourth presentation of phrase A (A1.4) generates a continuing increase in expectedness in response to each pitch, including the major 3rd, whereby ratings increase by 2 points (see pitches 3-4 in A1.4, trial 1, Table 3.9).

These results indicate the presence of varying perceptual processes, that can be categorised as schematic, within-group and veridical expectations, and thus explained using zygonic theory to capture how expectations might change as a function of stimulus repetition. Firstly, each rehearing of phrase A leads to a change in expectedness that indicates an increasing familiarity that alters according to how recently the phrase was heard. For example, the amount of surprise in response to the major 3rd in phrase A lessens over time (e.g. from A1.1 to A1.2, and then A1.3 to A1.4 (see Figure 3.7 and Table 3.9) which indicates a cumulative effect of between-group repetition and thus an increasing dominance of veridical expectations. Meanwhile, a decrease in expectedness for the major 3rd presented in phrase A1.3 when compared with phrase A1.2 indicates that the recency of phrase repetition also impacts expectations. Secondly, within-group expectations in zygonic terms describe an expectation for pattern continuation. This accords with the finding that participants tend to be surprised by the major 3rd which disrupts the established pattern. This occurs throughout trial 1 despite the repetition (except for A1.4), which implies that within-group expectations are consistent in the context of melodic repetition.

3.3.2 Phrase A repeated trials

In terms of repeated trials, further evidence of a systematic and cumulative effect of between-group expectations and the preservation of within-group expectations is apparent.

- Expectations in response to trial 2 are similar to the first; each major 2nd is rated as expected, and each major 3rd is rated as unexpected. In this case, the 1-point decrease in expectedness for A1.4 in trial 2 differs from the 2-point increase in expectedness for A1.4 in trial 1 (see pitches 3-4, A1.4 in Figure 3.8).
- The pattern of expectation continues throughout trials 3 and 4 whereby each major 2nd corresponds with an increase in expectedness, and each major 3rd corresponds with a decrease in expectedness to a lessening degree with each exposure. There are two exceptions: where the rating does not change (trial 3: pitches 3-4, A1.4), and where the expectancy rating increases by 1 point (trial 4: pitches 3-4, A1.4).
- During all trials in session 2, the response pattern continues. Ratings increase for each major 2nd, and decrease for each major 3rd, lessening each time the melody unfolds. This is notwithstanding two occasions whereby ratings in response to the major 2nd do not change (trial 6: pitches 3-4, A1.2 and pitches 3-4, A1.4, Table 3.10), and one instance whereby the expectancy rating increases by 1 point (trial 8: pitches 3-4, A1.2).

Overall, the rating pattern across both sessions shows that the major 2nd is expected, and the major 3rd is surprising, except for the occasions noted above. These findings demonstrate the persistence of within-group expectations, whereby expectations for pattern continuation give rise to a sense of surprise when the pattern is disturbed, even having been exposed to the same pattern numerous times.

3.3.3 Phrase B first trial

Ratings for phrase B during the first trial reveal expectations that accord with high level principles, as highlighted below.

- Pitches 1-3 in B1 generate a descending melodic pattern that infers a within-group expectation, but participants' ratings do not reflect this. As predicted, the change in melodic direction at pitch 4 in B1 is perceived as unexpected.
- The implied closure at pitch 5 in B1 and B2 is perceived as expected.
- Pitch 3 in B2 is rated as surprising, which reveals a difference in how phrase B1 and B2 are perceived.

The first trial reveals similarities and differences between phrases B1 and B2. Both phrases generate an expectation for closure that is underlined by an understanding of tonality at phrase boundaries. This demonstrates schematic expectations. It is likely that the dissimilarity between phrase B1 and B2 is because they appear at a different pitch level which generates expectations weighted by distinct principles. The principles that govern phrase B1 may relate to within-group pattern disruption, whereas those that govern phrase B2 may be weighted by pitch range or sensory perception since pitch 3 in B2 is the melody's lowest pitch. Furthermore, it is acknowledged in the zygonic model set out in Thorpe et al. (2012), that mid-range pitches appear more frequently than pitches at the extremes, which is reflected by the unexpectedness of pitch 3 in B2.

3.3.4 Phrase B repeated trials

Visual observation of all trials shows that the first three pitches in phrase B1 and B2 generate inconsistent ratings. However, the expectation for closure in phrases B1 and B2 is consistent across all trials.

- A consistent rating pattern for pitches 3-4 and 4-5 in B1 demonstrates surprise at the change in direction followed by an expectation for closure (see Tables 3.9 and 3.10).
- The same results are observed for pitches 3-4, and 4-5 in B2. This contrasts with trial 1 which reveals that pitch 3 in B2 is the most surprising pitch in the melody. Instead, pitch 4 in B1 and B2 are the least expected throughout all remaining trials.

Participants are consistently surprised by pitch 4 in B1 and B2 despite the cumulating influence of veridical expectations. Participants' ratings for pitch 4 in phrase B may be due to the projection of a) within-group expectations; or b) inverted between-group expectations. For example, participants may expect a descending pattern continuation and are surprised to hear a change in direction at pitch 4 in B1 and B2 representing the activation of within-group expectations. Alternatively, after being twice presented with phrase A, participants may expect to hear the opening four notes of phrase A in a reversed transposition (see A1.2 and B1 in Figure 3.7) leading to surprise when presented with pitch 4 in B1 (a change in direction), that is not yet an established pattern. These results indicate that the between-group and within-group expectations that cause said low ratings, are resistant to the participants' growing familiarity with the stimulus. Additionally, participants are consistently surprised by the pattern disruption that occurs in the penultimate pitch in phrases B1 and B2, even though it indicates closure, and even though the phrases are repeated across the eight trials. This implies that the within-group or schematic expectations are robust and deep-seated.

3.3.5 Rating distribution

Visual inspection of Figures 3.8 and 3.9 reveal a flattening contour with each trial, indicating a subtle change in the balance between the differing expectational forces. Table 3.11 presents the difference in expectancy ratings between each pitch, revealing a mean score that decreases with each trial throughout session 1, resets between the sessions, and decreases again during session 2. This was calculated for each trial by taking the mean rating for each pitch, calculating the difference between each adjacent pitch mean, summing each difference and then dividing by the number of pitches. This supports the idea that as familiarity increases, the dispersion of ratings decreases which is indicative of a strengthening influence of veridical expectations in response to melodic repetition.

Table 3.11. Aggregated mean differences between pitches, split by trial.

Trial	All pitches	Mean
Session 1	Trial 1	8.531
	Trial 2	6.732
	Trial 3	6.040
	Trial 4	5.109
Session 2	Trial 5	10.223
	Trial 6	7.201
	Trial 7	4.170
	Trial 8	4.872

Table 3.12. Autocorrelation coefficients (ø) for sessions 1 and 2.

Session	Intercept	*p value*	ϕ	*p value*	Std D
Session 1	102.465	0.000***	0.505	0.000***	2.414
Session 2	108.569	0.000***	0.473	0.000***	3.055

*p < .05. **p < .01. ***p < .001.

Table 3.13. Autocorrelation coefficients (ø) for trials 1-8.

Session	Trial	Intercept	*p value*	ϕ	*p value*	Std D
Session 1	Trial 1	91.925	0.000***	0.457	0.000***	3.145
	Trial 2	100.952	0.000***	0.487	0.000***	3.22
	Trial 3	107.628	0.000***	0.543	0.000***	3.554
	Trial 4	107.321	0.000***	0.516	0.000***	4.275
Session 2	Trial 5	101.552	0.000***	0.363	0.002**	3.479
	Trial 6	109.011	0.000***	0.444	0.000***	3.761
	Trial 7	110.845	0.000***	0.622	0.000***	4.479
	Trial 8	113.125	0.000***	0.514	0.000***	3.638

*$p < .05$. **$p < .01$. ***$p < .001$.

A second method of observing the contour change is to assess the autocorrelation of expectancy ratings using time series analysis which measures the correlation between the rating for each pitch and its predecessor, resulting in a mean rating (intercept) and a correlation coefficient for each set of ratings. Time series analysis was first conducted for all pitches separated by sessions 1 and 2, resulting in a significant autocorrelation for both sessions (Table 3.12). Next, the autocorrelation coefficient was calculated for trials 1-8, yielding a significant coefficient for each trial as shown in Table 3.13. These results demonstrate that high ratings follow high ratings, and low ratings follow low ratings. The correlation coefficient, ø, is of particular interest, as this measures the strength of the correlation, and thus can be viewed as the level of variance in the rating contour. It was hypothesised that the ø value would increase with each trial, reduce during the break between sessions, and increase throughout session 2, and although this trend can be seen visually in Table 3.13, there are no significant differences between the trials.

3.4 Exploration of questionnaire items

A series of multiple linear regression models were performed to investigate whether any of the questionnaire items could predict participants' expectancy ratings, for reasons discussed in the methods chapter. The independent variables were a) gender; b) months of formal musical training; and c) minutes spent listening to music per week. Gender was categorised as a dummy variable, coded 0 for females and 1 for males. The other two variables were continuous. Regression was the preferred method of analysis due to the wide age range across all three experiments and thus the wide range of training. A regression was performed for each of the following pitch combinations:

- All 200 pitches in session 1 (model 1)
- All 200 pitches in session 2 (model 2)
- Phrase A 60 pitches in session 1 (model 3)
- Phrase A 60 pitches in session 2 (model 4)
- Phrase B 40 pitches in session 1 (model 5)
- Phrase B 40 pitches in session 2 (model 6)

As depicted in Tables 3.14, 3.15, and 3.16, the results revealed that formal music training and weekly minutes of music listening were not significant predictors for participants' performance on the rating task. A gender difference was apparent in both sessions when analysing the whole melody and phrase A, but not for phrase B.

Table 3.14. Whole melody. Multiple regression model 1 (session 1) and model 2 (session 2).

	Session 1 - whole melody				Session 2 - whole melody			
Variable	***B***	***SE***	***β***	***p* value**	***B***	***SE***	***β***	***p* value**
Constant	94.534	4.132		0.000	97.52	4.692		0.000
Gender	13.474	4.665	0.461	0.007**	15.616	5.263	0.498	0.006**
Months training	0.022	0.036	0.096	0.538	0.022	0.039	0.091	0.579
Mins listening	-0.002	0.003	-0.113	0.482	0	0.003	-0.026	0.88
R	0.466				0.509			
R square	0.217				0.259			
Adjusted R sq.	0.148				0.183			
F	3.137			0.038*	3.387			0.031*

*N=38. *p < .05. **p < .01. ***p < .001.* *N=33*

Table 3.15. Phrase A. Multiple regression model 3 (session 1) and model 4 (session 2).

	Session 1 - phrase A				Session 2 - phrase A			
Variable	***B***	***SE***	***β***	***p* value**	***B***	***SE***	***β***	***p* value**
Constant	97.327	3.89		0.000	100.82	4.066		0.000
Gender	13.897	4.391	0.476	0.003**	14.926	4.561	0.518	0.003**
Months training	0.025	0.034	0.105	0.474	0.032	0.034	0.144	0.354
Mins listening	0.002	0.003	0.139	0.362	0.002	0.003	0.108	0.502
R	0.549				0.585			
R square	0.302				0.343			
Adjusted R sq.	0.24				0.275			
F	4.899			0.006**	5.039			0.006**

*N=38. *p < .05. **p < .01. ***p < .001.* *N=33*

Table 3.16. Phrase B. Multiple regression model 5 (session 1) and model 6 (session 2).

	Session 1 - phrase B				Session 2 - phrase B			
Variable	***B***	***SE***	***β***	***p* value**	***B***	***SE***	***β***	***p* value**
Constant	90.452	5.603		0.000	92.726	6.373		0.000
Gender	12.684	6.325	0.325	0.053	16.213	7.148	0.406	0.031
Months training	0.021	0.049	0.066	0.674	0.009	0.053	0.03	0.862
Mins listening	-0.008	0.004	-0.369	0.029	-0.004	0.004	-0.165	0.364
R	0.435				0.399			
R square	0.189				0.159			
Adjusted R sq.	0.118				0.072			
F	2.648			0.065	1.829			0.164

*N=38. *p < .05. **p < .01. ***p < .001.*

N=33

Regression model 1 (200 pitches across session 1) reveals that males rated 13.474 points higher than females on the expectancy scale, and the second regression model (200 pitches across session 2) shows that males rated 15.616 points higher than females on the expectancy scale. Males' ratings for phrase A (60 pitches) were 13.897 points higher than females' ratings (p = .003) during session 1, and 14.926 points higher than females during session 2 (p = .003). Over phrase B's 40 pitches in session 1, males' ratings are not significantly different to females, as indicated by the non-significant models in Table 3.16. Similarly, ratings for phrase B during session 2 are not significantly different between genders. Although the effect size is moderate, as shown by the β values in Tables 3.15 and 3.16, it is worth reiterating that the gender balance is unequal (see Table 3.1), as are the musical backgrounds of male and female participants, therefore difference may be due to reasons that have not been adequately controlled for here. This will be explored in the discussion section.

3.5 Chapter discussion and summary

This chapter presents the results for the first of three experiments. The central research objective for this experiment was to examine adults' expectancy ratings in response to repetition of a melodic stimulus, and to investigate how schematic, veridical, and within-group expectations interact in response to melodic repetition. Analysis was directed at three levels: sessions, trials, and pitch, and was informed by Ockelford's zygonic theory (2006, 2012) which offers a theoretical basis for investigating repeated listening to music. Analysis was also influenced by research on Gestalt-based perceptual laws that may apply to us all (Huron, 2006). The results presented in this chapter provide the first empirical evidence for (a) an influence of repetition that is affected by (b) recency of occurrence on the local (phrase) and global (stimulus) level, demonstrating fluctuations in dominance between schematic and veridical expectations. These interpretations will be elaborated on in the discussion chapter.

As hypothesised in section 1.5.2 of the literature review, the findings presented here demonstrate the persistence of schematic expectations (Bigand et al., 2005; Marmel, Tillmann & Delbé, 2010; Tillmann & Bigand, 2010), yet adds a more nuanced portrayal of how the relationship between schematic and veridical expectations evolve over time in response to repeated exposures to a melody, with the addition of within-group expectations. Specifically, schematic expectations (the influence of which are represented by the expectancy rating contour) are not steadfast as hypothesised, but they are responsive to repetition, as demonstrated by the flattening contour with each stimulus repetition, representing a weakening influence. As expected, within-group expectations are deep-rooted and thus are reported to be influential throughout the experiment as demonstrated by consistent surprise when unfolding patterns are disrupted.

Furthermore, veridical expectations function as hypothesised, in that they increase in dominance with each exposure, followed by a decay during the break between sessions, after which they kick in more rapidly once the melody is resumed. A multiple regression reveals a significant effect of gender, but the reason for this is not clear and will be explored in the discussion. In summary, this is the first study to empirically demonstrate the changing balance in dominance between schematic, within-group, and veridical expectations that occurs in response to repetition of a melodic stimulus. Caution should be taken when applying the results to real-world settings as music is more likely to be self-selected which may alter the strength of predictions. Nevertheless, the cognitive processes generally occur non-consciously therefore it is plausible that expectations will behave similarly whether the familiar music is self-selected or experimentally-selected. Limitations and implications of these will be explored in the discussion chapter.

4 Results: Typically developing children

This chapter reports results from the second of three experiments, which investigates the melodic expectations of typically developing (TD) children who are familiar with Western music, categorised into three age groups: 6-8, 9-12, and 13-17. Children underwent the same procedure as adults. The research objective for this experiment is to focus on the second research question set out in the literature review, which is to investigate the normative age trends in relation to the interplay between schematic, veridical and within-group expectations. Analysis is informed by zygonic theory and principles of melody perception (Ockelford, 2016, 2012).

Table 4.1. TD children. Participant totals.

Participant group	Gender	Session 1	Session 2
TD children aged 6-8	Male	25	25
	Female	19	19
	Total	44	44
TD children aged 9-12	Male	19	19
	Female	30	30
	Total	49	49
TD children aged 13-17	Male	35	32
	Female	27	26
	Total	62	58

4.1 Participants

Age category 1 consists of 44 children aged 6-8 (25 male and 19 female). One child in this category attended his second session four days after the first. All other children attended their second session one week after the first session. 50% of children in this category received private instrumental (including vocal) outside of the school curriculum, the majority of whom played strings (53%), woodwind (26%), and brass (17%). The remainder played a combination of strings and woodwind (4%). Of the 39 respondents who reported listening to music, 38 reported listening to music for 10 hours or less per week, and one participant reported listening for 12 hours per week. 80% of this age category were British, and the remainder were British mixed with French, Australian, Indian, South African, African, Russian, Welsh, or Jordanian.

Age category 2 consists of 50 children aged 9-12 (19 male and 31 female). One participant attended their second session four days after the first. A second participant waited 14 days between sessions 1 and 2, and another participant waited for 19 days between sessions. All other participants attended their second session one week after the first. 54% of children in this category received formal instrumental or voice tuition. These pupils were trained on woodwind (35%), strings (27%), brass (12%), voice (12%), strings and woodwind (8%), brass and strings (4%) or percussion (4%). Of the 47 respondents who reported listening to music, 46 reported listening for 10 hours or less per week, and one participant reported listening for 21 hours per week. 60% of this group are British. 34% were British mixed with American, French, Australian, Sri-Lankan, Welsh, Indian, South African, Thai, Chinese, Philippines, or Mauritian. There was also one Italian, one Chinese and one Turkish participant.

Age category 3 consists of 62 children aged 13-17 (25 male and 27 female). One participant attended their second session 14 days after the first. All other participants attended their second session one week after the first session. 49% of this group had received formal instrumental or voice tuition. Of those who had undergone formal tuition, 29% were trained on strings, 16% were trained on voice, 16% on woodwind, 10% on brass, and the remainder played a combination of strings, woodwind, brass, percussion or voice. Of the 59 respondents who reported listening to music, 35 reported listening for 10 hours or less per week, 16 reported listening for between 10 and 20 hours per week, and eight reported listening for between 21-50 hours per week. 88% of this group were British. The remainder were British-mixed with American, Indian, Irish, or Jordanian.

4.3 Session and trial level analysis (quantitative)

Section 4.3 presents results from a series of ANOVAs that compared responses for the melodic stimulus as a whole (subsection 4.3.2); phrase A (subsection 4.3.3), and phrase B (subsection 4.3.4). Analysis occurs at the session and trial levels within each age category, after which age group comparisons are conducted. Normality tests are provided in Appendix B.

4.3.2 Whole melody

This section reports quantitative analyses of the melody as a whole and is guided by the hypothesis that awareness of phrase and melody repetition will increase with age (Voyajolu and Ockelford, 2016). This is achieved by investigating variance in expectancy ratings between sessions 1 and 2, and between each trial, followed by age group comparisons.

4.3.2.1 Within-group analysis

A two-way repeated measures 2 x 3 ANOVA with session (1/2) as the within-subjects factor and age category (6-8/9-12/13-17) as the between-subjects factor revealed a significant difference between participants' expectancy ratings for sessions 1 and 2 $F(1, 147) = 30.706$, $p = .000$, partial $\eta^2 = .173$. There was no significant interaction between session and age category $F(1, 2) = 2.556$, $p = .081$, partial $\eta^2 = .034$, indicating that the difference in mean expectancy ratings between sessions 1 and 2 was not affected by age. This overall finding implies that at the session level, melody repetition may influence all participants.

Figures 4.1, 4.2 and 4.3 display each participant group's mean ratings for trials 1-8, which shows a visual trend for all groups to exhibit an increase in expectedness during session 1, a small decrease between sessions and a further increase during session 2. This pattern becomes more apparent as children grow older. Children's ratings were quantitatively assessed using a repeated measures ANOVA with trial as the within-subjects factor.

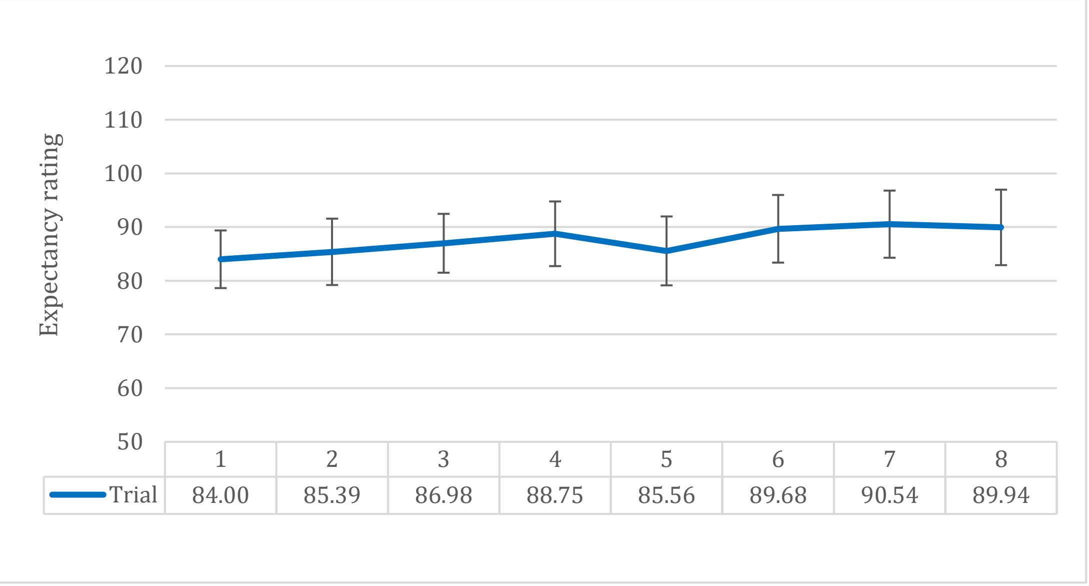


Figure 4.1. TD children aged 6-8. Mean expectancy ratings for trials 1-8, whole melody.

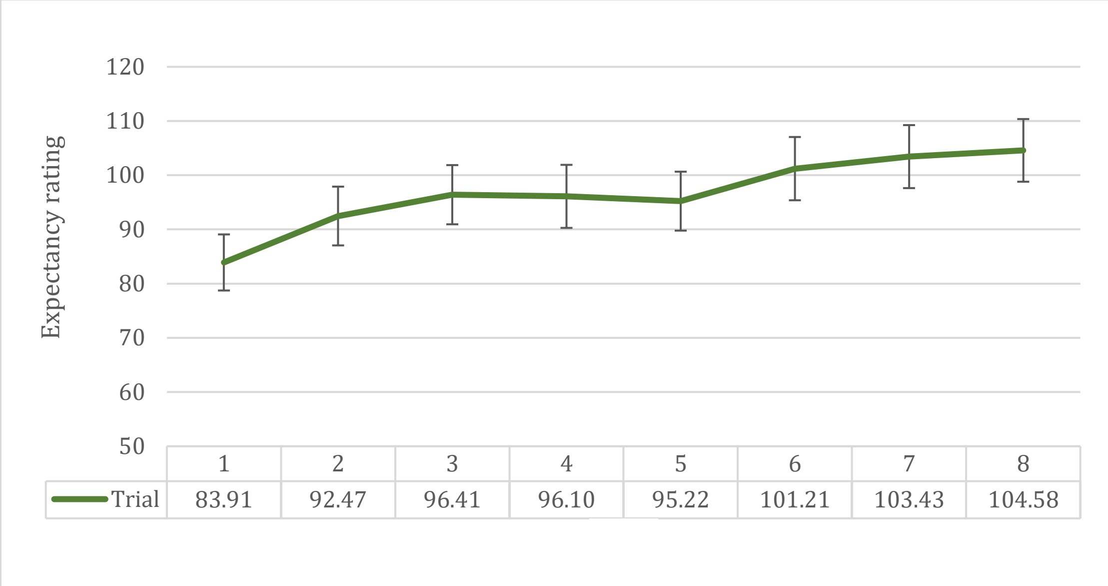


Figure 4.2. TD children aged 9-12. Mean expectancy ratings for trials 1-8, whole melody.

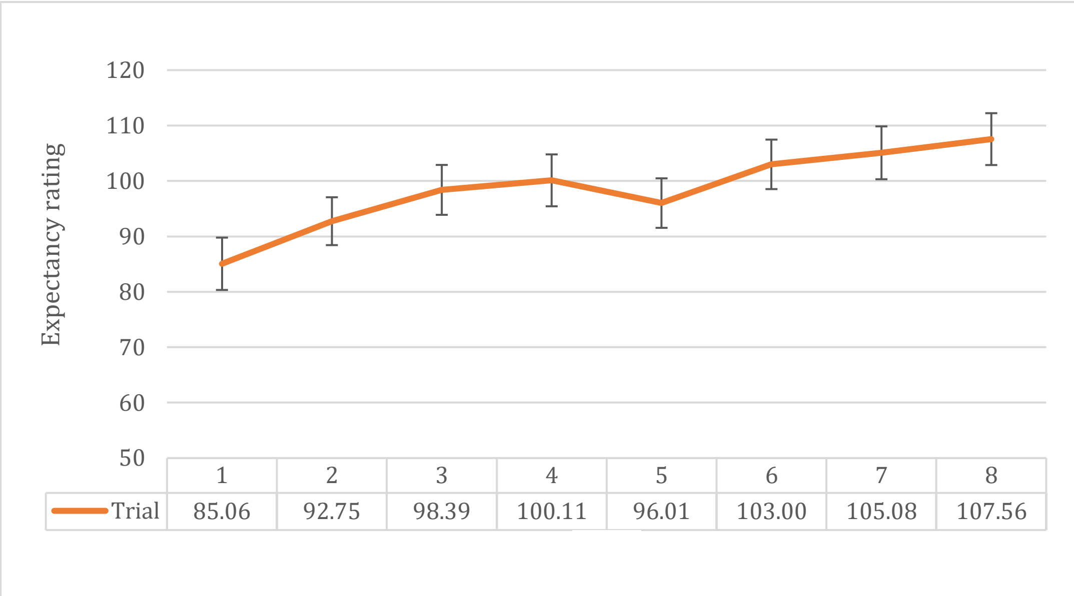


Figure 4.3. TD children aged 13-17. Mean expectancy ratings for trials 1-8, whole melody.

Children aged 6-8

Figure 4.1 shows that children aged 6-8 demonstrate a small increase in expectedness throughout session 1, a decrease between sessions and a further minimal increase between trials 5 and 6, followed by a stasis in scores for trials 7 and 8. There was no significant main effect found between trials, $F(2.954, 127.028) = 1.319$, $p = .271$, partial $\eta^2 = .030$.

Children aged 9-12

Variance between trials was examined for children aged 9-12, whereby a significant main effect of trial with a moderate effect size was found *F*(2.729, 128.283) = 16.385, $p = .000$, partial $\eta^2 = .259$. Tests of within-subjects contrasts (Table 4.11) reveal that ratings increase significantly between trials 1-2, 2-3, and 5-6, indicating that children aged 9-12 are most sensitive to melody repetition that occurs between the first and second trials during each session, demonstrating an early increase in familiarity that stabilises after the third trial in session 1, and at a sooner point – after the second trial – during session 2.

Table 4.2. TD children aged 9-12. Repeated measures ANOVA contrasts for trials 1-8, whole melody.

Session	Trial	F	*p* value	Partial eta squared
Session 1	1-2	17.093	0.000***	0.267
	2-3	7.161	0.05*	0.132
	3-4	0.03	1.000	0.001
	4-5	0.179	1.000	0.004
Session 2	5-6	19.114	0.000***	0.289
	6-7	1.707	0.792	0.035
	7-8	1.094	0.903	0.023

*$p < .05$. **$p < .01$. ***$p < .001$.

Children aged 13-17

The final ANOVA in this section examined the variance between eight trials for 13-17-year-olds where a significant main effect of trial was found *F*(3.521, 200.669 = 32.747, $p = .000$, partial $\eta^2 = .365$. The mean expectancy ratings relating to this are shown in Figure 4.1. Within-subjects contrasts (Table 4.3) reveal that expectedness increases significantly between trials 1-2 and 2-3 and between trials 5-6.

Table 4.3. TD children aged 13-17. Repeated measures ANOVA contrasts for trials 1-8.

Session	Trial	F	*p* value	Partial eta squared
Session 1	1-2	22.76	0.000***	0.285
	2-3	22.46	0.000***	0.283
	3-4	2.338	0.132	0.039
Session 2	4-5	5.644	0.064	0.09
	5-6	31.199	0.000***	0.354
	6-7	3.718	0.118	0.061
	7-8	6.224	0.064	0.098

*$p < .05$. **$p < .01$. ***$p < .001$.

Summary

The above analyses reveal an influence of repetition that occurs in stages. For example, the non-significant result of 6-8-year-olds indicates that this aspect of melody perception is still developing. Stimulus repetition becomes more influential between the ages of 9-12, as demonstrated by the significant increase in expectedness between the first and second trials in each session. At this point, children are aware that they have heard the stimulus before, but the degree of recognition does not inflate in response to further repetitions. Similarly, 13-17-year-olds also show a sensitivity to stimulus repetition early on during each session. Despite the finding that there was no significant main effect of session on age category, these trial-level analyses suggest that as children grow older, their perception of melody repetition alters. The cognitive and perceptual processes that underlie this finding will be explored in the discussion chapter.

4.3.2.2 Between-group analysis

This section explores whether age groups differ by trial. Firstly, a two-way 8 x 3 repeated measures ANOVA with trial as the within-subjects factor and age category as the between-subjects factor was conducted to determine whether there was an overall significant interaction between trial repetition and age. Results reveal a significant effect for trial x age category with a small effect size $F(6.413, 471.384) = 2.670$, $p = .013$, partial $\eta^2 = .035$. A Tukey HSD post-hoc test reveals that the mean ratings of children age 6-8 were significantly lower than those of 9-12-year-olds ($p = .017$) and children aged 13-17 ($p = .002$), but that 9-12-year-olds' expectancy ratings were not significantly lower than 13-17-year-olds ($p = .828$).

Thereafter, a univariate ANOVA with age category as the between-subjects factor was performed separately for each trial (see Table 4.4). There was no significant main effect for trials 1 and 2 which indicates that ratings were similar for all groups. However, trials 3-8 reveal a significant effect of age category which enlarges with each stimulus repetition as indicated by the increasing effect size. Table 4.5 presents Tukey HSD post-hoc tests for each significant trial, demonstrating that during each trial 6-8-year-olds' ratings were significantly lower than children aged 9-12 and 13-17, and that children aged 9-12 did not differ from 13-17-year-olds. The only exception is that in trial 4, there is no significant difference between children aged 6-8 and 9-12.

Table 4.4. Repeated measures ANOVA for trial x age category.

Trial	**F**	***p* value**	**Partial eta squared**
Trial 1	0.07	0.933	0.001
Trial 2	2.393	0.095	0.031
Trial 3	5.423	0.005**	0.067
Trial 4	4.428	.014*	0.055
Trial 5	4.471	.013*	0.057
Trial 6	6.707	.002**	0.083
Trial 7	7.838	.001**	0.096
Trial 8	10.367	.000***	0.123

*$p < .05$. **$p < .01$. ***$p < .001$.

Table 4.5. Tukey post-hoc tests comparing age category for trials with a sig. main effect.

Trial	Participant group	*p* value
Trial 3	6-8 - 9-12	0.037*
	6-8 - 13-17	0.005**
	9-12 - 13-17	0.836
Trial 4	6-8 - 9-12	0.166
	6-8 - 13-17	0.01**
	9-12 - 13-17	0.526
Trial 5	6-8 - 9-12	0.039*
	6-8 - 13-17	0.017*
	9-12 - 13-17	0.975
Trial 6	6-8 - 9-12	0.012*
	6-8 - 13-17	0.002**
	9-12 - 13-17	0.882
Trial 7	6-8 - 9-12	0.005**
	6-8 - 13-17	0.001***
	9-12 - 13-17	0.901
Trial 8	6-8 - 9-12	0.002**
	6-8 - 13-17	0.000***
	9-12 - 13-17	0.729

*$p < .05$. **$p < .01$. ***$p < .001$.

The results from the above two paragraphs suggest that children aged 6-8 are unique in their responses, possibly due to developmental differences in memory function. It is also implied that children aged 9-12 respond similarly to 13-17-year-olds, indicating that the rate of developmental change slows at some point during the transition between the two age boundaries, as indicated by Hargreaves and Lamont (2017). With respect to the framework offered by zygonic theory, the results in this section show that veridical expectations become more influential as children grow older, but it does not shed light on how schematic and within-group expectations might operate. As discussed in the methods chapter, schematic, and within-group expectations are measurable at the phrase and pitch levels.

4.3.3 Phrase A

4.3.3.1 Within-group analysis

Within each age category, a repeated measures ANOVA with trial as the within-subjects condition was run to determine whether expectations varied as a function of phrase A repetition. Figures 4.4, 4.5 and 4.6 display mean expectancy ratings for trials 1-8 separated by age category. The visual trends are similar to those seen in Figures 4.1-4.3, where an increase in expectedness occurs during session 1, dips between sessions, and increases to a greater degree in session 2. Again, consistency with this pattern increases as age increases.

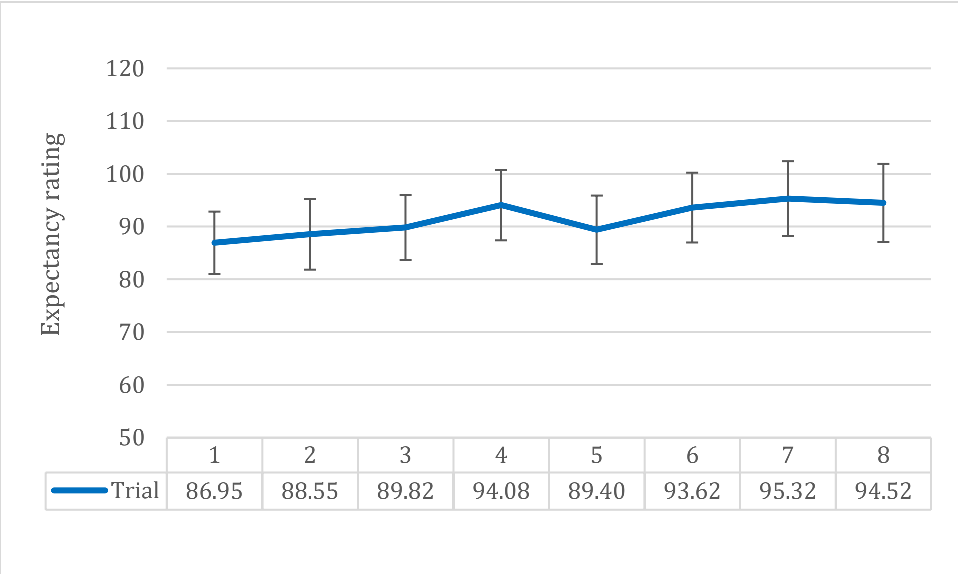


Figure 4.4. TD children aged 6-8. Mean expectancy ratings for trials 1-8, phrase A.

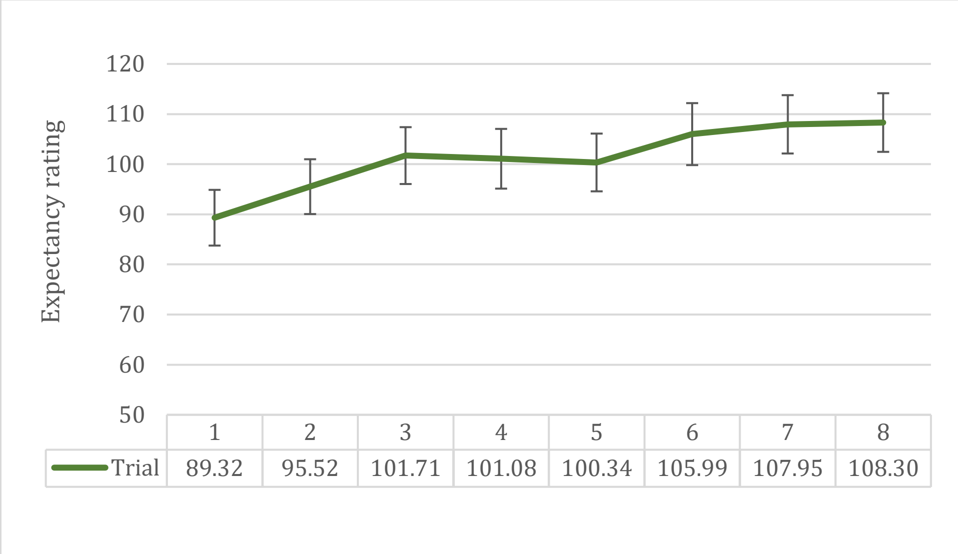


Figure 4.5. TD children aged 9-12. Mean expectancy ratings for trials 1-8, phrase A.

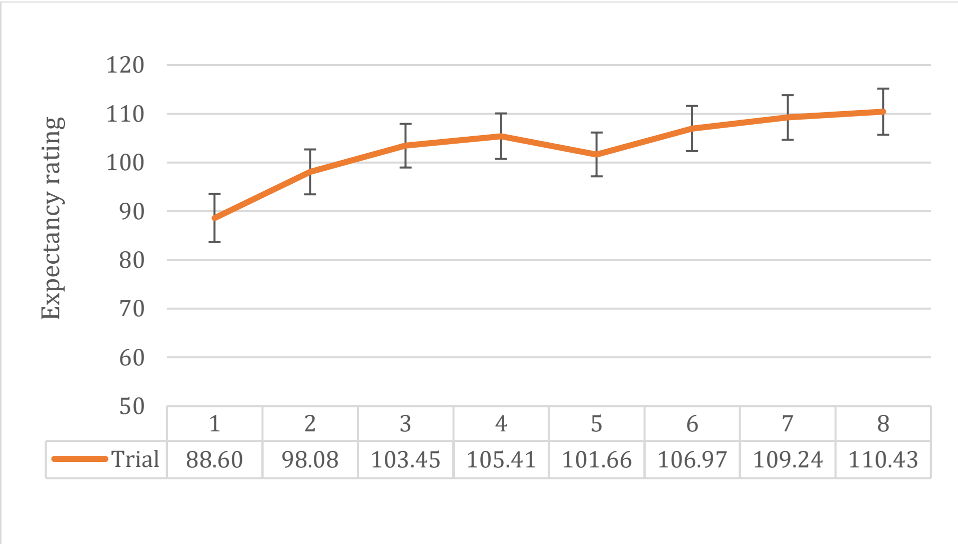


Figure 4.6. TD children aged 13-17. Mean expectancy ratings for trials 1-8, phrase A.

Children aged 6-8

Children aged 6-8 were not found to be significantly influenced by trial $F(3.533, 151.936) = 2.085$, $p = .095$, partial $\eta^2 = .266$, mirroring the above results pertaining to the whole melody. It can be inferred that despite the frequent repetition of phrase A, 6-8-year-olds' expectations are unaffected.

Children aged 9-12

Children aged 9-12 were significantly influenced by trial $F(2.729, 128.283) = 16.385$, $p = .000$, partial $\eta^2 = .554$ (see Figure 4.2 and Table 4.15). Within-subjects contrasts reveal that expectedness increases significantly from trials 1-2, 2-3, and 5-6. These results are similar to those found at the whole melody level whereby expectedness increases more quickly in session 2.

Table 4.15. TD children aged 9-12. Repeated measures ANOVA contrasts for trials 1-8, phrase A.

Session	Trial	F	*p* value	Partial eta squared
Session 1	1-2	11.276	0.010*	0.193
	2-3	11.97	0.006**	0.203
	3-4	0.105	1.000	0.002
	4-5	0.119	1.000	0.003
Session 2	5-6	16.847	0.000***	0.264
	6-7	1.405	0.968	0.029
	7-8	0.031	1.000	0.001

*p < .05. **p < .01. ***p < .001.

Children aged 13-17

A significant main effect of trial was also found for 13-17-year-olds $F(3.407, 194.222) = 29.594$, $p = .000$, partial $\eta^2 = .627$. Tests of within-subjects contrasts show that differences between trials are similar to the whole melody analysis whereby expectedness increases significantly between trials 1-2, 2-3 and 5-6, implying that expectedness peaks more quickly in session 2.

Table 4.16. TD children aged 13-17. Repeated measures ANOVA contrasts for trials 1-8, phrase A.

Session	Trial	F	*p* value	Partial eta squared
Session 1	1-2	25.142	0.000***	0.306
	2-3	16.458	0.000***	0.224
	3-4	3.988	0.153	0.065
Session 2	4-5	5.814	0.076	0.093
	5-6	17.936	0.000***	0.239
	6-7	3.826	0.153	0.063
	7-8	1.853	0.179	0.031

*p < .05. **p < .01. ***p < .001.

4.3.2.2 Between-group analysis

A univariate ANOVA with age category as the between-subjects factor was performed separately for each trial to determine how participants of different ages compared at each trial. As presented in Table 4.17, a significant effect of age category was found for all trials except trial 1. A Tukey HSD post-hoc test was performed for each significant trial, the results of which are displayed in Table 4.18, demonstrating that for trials 3, 5, 6, 7, and 8, 6-8-year-olds' ratings were significantly lower than children aged 9-12 and 13-17, and that children aged 9-12 did not differ from 13-17-year-olds. In trials 2 and 4, 6-8-year-olds differed to 13-17-year-olds.

Table 4.17. TD children. Repeated measures ANOVA for trial (phrase A) x age.

Trial	F	*p* value	Partial eta squared
Trial 1	0.18	0.835	0.002
Trial 2	3.126	0.047*	0.04
Trial 3	7.296	0.001**	0.088
Trial 4	4.052	0.019*	0.051
Trial 5	5.698	0.004**	0.071
Trial 6	6.394	0.002**	0.08
Trial 7	6.867	0.001***	0.085
Trial 8	8.197	0.000*	0.1

*p < .05. **p < .01. ***p < .001.

Table 4.18. TD children. Tukey HSD post-hoc tests comparing age category for phrase A trials with a significant main effect.

Trial	Participant group	*p* value
Trial 2	6-8 - 9-12	0.204
	6-8 - 13-17	0.039*
	9-12 - 13-17	0.773
Trial 3	6-8 - 9-12	0.009**
	6-8 - 13-17	0.001**
	9-12 - 13-17	0.882
Trial 4	6-8 - 9-12	0.221
	6-8 - 13-17	0.014*
	9-12 - 13-17	0.502
Trial 5	6-8 - 9-12	0.02**
	6-8 - 13-17	0.005**
	9-12 - 13-17	0.935
Trial 6	6-8 - 9-12	0.010**
	6-8 - 13-17	0.003**
	9-12 - 13-17	0.966
Trial 7	6-8 - 9-12	0.008**
	6-8 - 13-17	0.002**
	9-12 - 13-17	0.942
Trial 8	6-8 - 9-12	0.005**
	6-8 - 13-17	0.001**
	9-12 - 13-17	0.858

*$p < .05$. **$p < .01$. ***$p < .001$.

The results in this section show that for each age category, the expectancy ratings for phrase A exaggerate the ratings found at the whole melody level, in that phrase A leads to higher mean expectancy ratings across all trials. This accords with the hypothesis that the increased repetition frequency of phrase A leads to a greater sense of expectedness for the phrase.

4.3.4 Phrase B

4.3.4.1 Within-group analysis

Within each age category, a repeated measures ANOVA with trial as the within-subjects condition was run to determine whether expectations varied as a result of phrase B repetition. Figures 4.7, 4.8 and 4.9 display mean expectancy ratings for trials 1-8 split by TD age category, showing that ratings for phrase B are less systematic than ratings for phrase A. For example, the youngest children exhibit a decrease in mean ratings over time, and 9-12-year-olds’ ratings are static for most of session 1. Older children demonstrate a rating pattern that is consistent with results for phrase A and the whole melody.

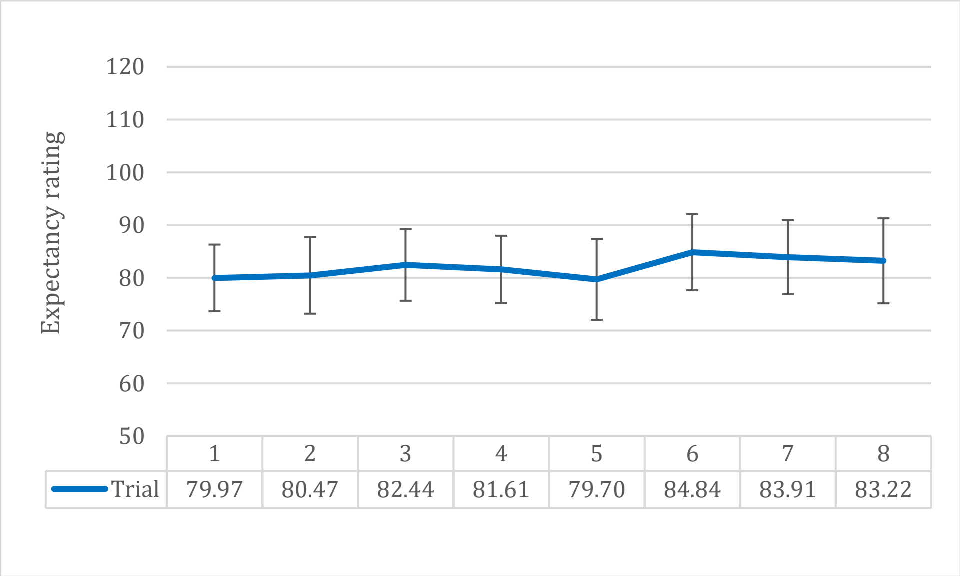


Figure 4.7. TD children aged 6-8. Mean expectancy ratings for trials 1-8 phrase B.

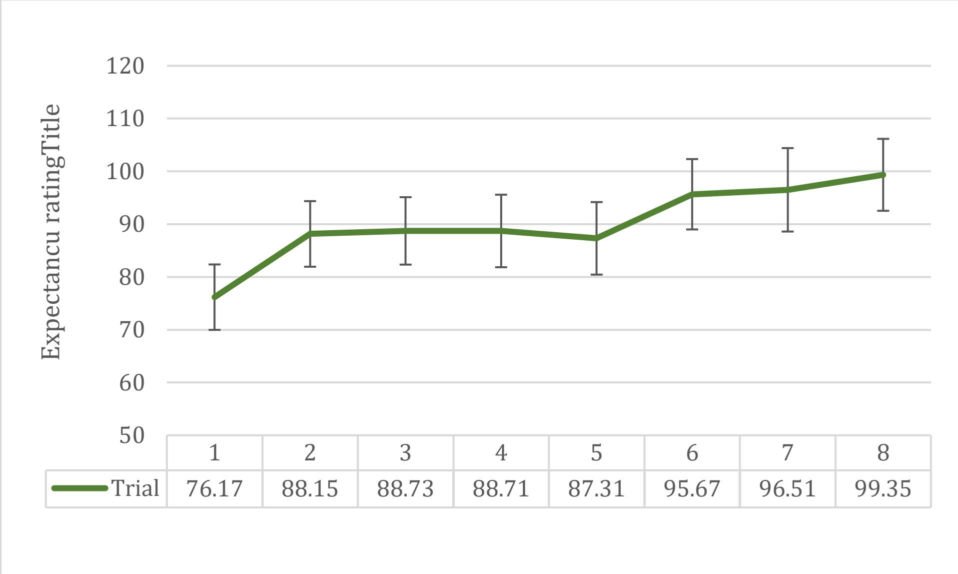


Figure 4.8. TD children aged 9-12. Mean expectancy ratings for trials 1-8 phrase B.

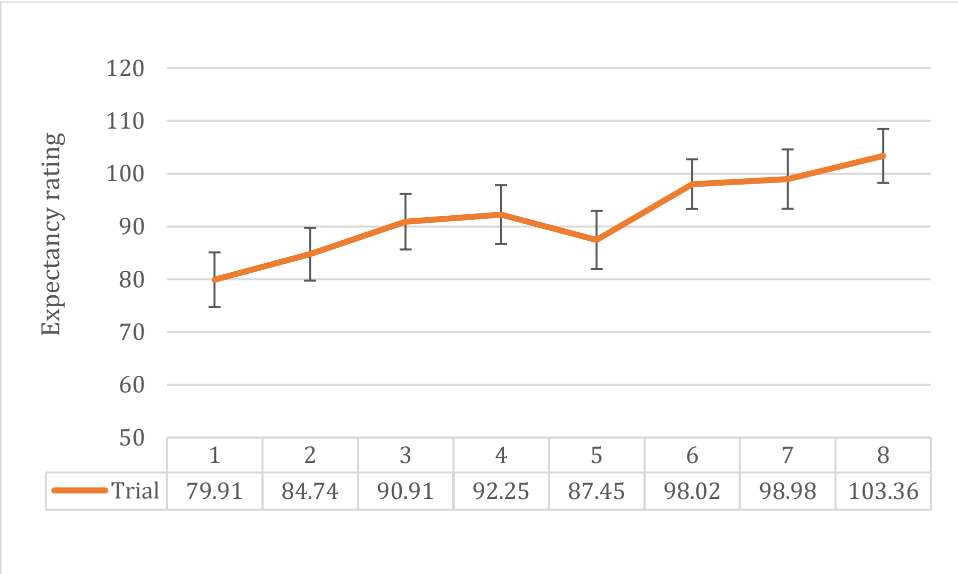


Figure 4.9. TD children aged 13-17. Mean expectancy ratings for trials 1-8 phrase B.

Children aged 6-8

No significant main effect of trial was found for children aged 6-8 $F(3.182, 133.655) = 0.482$, $p = .666$, partial $\eta^2 = .121$. As shown in Figure 4.6, there is no inclination for expectedness to change over time, suggesting that expectations for phrase B supported by complex processes that are undeveloped in 6-8-year-olds.

Children aged 9-12

A significant main effect was found for 9-12-year-olds $F(3.323, 156.174) = 10.487$, $p = .001$, partial $\eta^2 = .441$. Post-hoc contrasts show that expectancy ratings increase significantly from trials 1-2 in each session. This effect can be seen in Figure 4.3, whereby an initial growth in familiarity stabilises after trial 2.

Table 4.19. TD children aged 9-12. ANOVA contrasts for trials 1-8, phrase B.

Session	Trial	F	*p* value	Partial eta squared
Session 1	1-2	14.044	0.000***	0.23
	2-3	0.08	1.000	0.002
	3-4	0.001	1.000	.000
Session 2	4-5	0.269	1.000	0.006
	5-6	14.69	0.000***	0.238
	6-7	0.059	1.000	0.001
	7-8	1.924	0.860	0.039

$^*p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Children aged 13-17

A significant main effect was found for 13-17-year-olds $F(4.017, 228.941) = 23.638$, $p = .000$, partial $\eta^2 = .638$. Post-hoc contrasts show that expectedness increases significantly between trials 1-2, 2-3 and 5-6. The repetition of phrase B appears to be impactful for this age group, coinciding with the notion that complex cognitive processing develops with age. Figure 4.3 shows that the growth in expectedness occurs across all trials, but that within each session, the growth is not linear.

Table 4.20. TD children aged 13-17. ANOVA contrasts for trials 1-8, phrase B.

Session	Trial	F	*p* value	Partial eta squared
Session 1	1-2	8.083	0.024*	0.124
	2-3	11.115	0.012*	0.163
	3-4	0.349	1.000	0.006
	4-5	3.593	0.189	0.059
Session 2	5-6	35.287	0.000***	0.382
	6-7	0.396	1.000	0.007
	7-8	8.753	0.020*	0.133

*$p < .05$. **$p < .01$. ***$p < .001$.

4.3.3.2 Between-group analysis

A univariate ANOVA with age as the between-subjects factor was performed separately for each trial to determine how participants of varying ages compared at each trial. Table 4.21 shows that a significant effect of trial on age category was found for trials 6, 7, and 8. A Tukey HSD post-hoc test (Table 4.22) was performed for each significant trial, whereby children aged 6-8 responded differently to children aged 9-12 and 13-17, and children aged 9-12 did not differ from children aged 13-17. These results support the hypothesis that recognition of phrase B's repetition requires cognitive and perceptual processes that develop in later childhood years.

Table 4.21. TD children. Repeated measures ANOVA for trial (phrase B) x age.

Trial	F	*p* value	Partial eta squared
Trial 1	0.544	0.581	0.007
Trial 2	1.474	0.232	0.019
Trial 3	2.01	0.138	0.026
Trial 4	2.961	0.055	0.037
Trial 5	1.705	0.185	0.023
Trial 6	5.11	0.007**	0.065
Trial 7	5.394	0.005**	0.068
Trial 8	10.226	0.000***	0.121

*p < .05. **p < .01. ***p < .001.

Table 4.22. TD children. Tukey HSD post-hoc tests for significant trials, phrase B.

Trial	Participant group	*p* value
Trial 6	6-8 - 9-12	0.043*
	6-8 - 13-17	0.007**
	9-12 - 13-17	0.839
Trial 7	6-8 - 9-12	0.034*
	6-8 - 13-17	0.006**
	9-12 - 13-17	0.856
Trial 8	6-8 - 9-12	0.003**
	6-8 - 13-17	0.000***
	9-12 - 13-17	0.643

*p < .05. **p < .01. ***p < .001.

In summary, the results presented in section 4.3 show how the perception of phrase and melody repetition develops as children grow older. Children aged 6-8 do not exhibit significant sensitivities to repetition. This may be a result of developing memory capacity which causes children to focus on low-level and sensory aspects of melody with reduced global awareness. Visual inspection of plotted means displays an increase in expectedness in response to phrase A repetition but not to phrase B, which suggests that awareness of repeated pattern occurs at a sooner point compared to awareness of transposed pattern. A developmental change occurs in the next age bracket, concerning children aged 9-12. The expectancy ratings provided by children in this group imply that there is a marked increase in recognition between the first and second trial in each session for phrases A and B. Although expectations are reset between sessions, the difference is not significant. Children aged 13-17 appear to reach a greater sense of familiarity as indicated by higher expectancy ratings and smaller p-values. Phrases A and B both reveal significant differences between the first two trials in each session, whereas trials 2-3 are significantly different only for phrase B, which indicates some variation in how the phrases are perceived.

With respect to the research objective for this chapter, which is to establish how schematic, within-group and veridical expectations might develop in typically developing children, the results from this section highlight the operation of veridical expectations in that participants' sense of familiarity or recognition of stimulus repetition can be represented as veridical. Hence, as hypothesised, children aged 6-8 exhibit weak veridical expectations, whereas children aged 9-12 and children aged 13-17 exhibit stronger veridical expectations. The following section concerns schematic and within-group expectations.

4.4 Pitch level analysis (descriptive)

The current section presents pitch-by-pitch descriptive analyses for each age category. Thus far, analyses at the session and trial levels offer a global picture of how children's expectations develop in response to melodic repetition. Pitch-level analysis enables identification of schematic and within-group expectations at specific points throughout the experiment, exposing expectancy-based rating patterns that are influenced by the structural makeup of phrases A and B. This should highlight the functionality of the varying sources of expectation and how different pitch patterns might be perceived in children of varying ages. To recap, various melodic features such as pitch adjacency and pattern continuation have been identified in the methods chapter as aids for the descriptive analysis in this section. The melodic stimulus is displayed below in Figure 4.4. Analysis for each phrase focuses on the first trial followed by repeated trials. As discussed in the methods chapter, it may be that the first (novel) trial elicits a unique response.

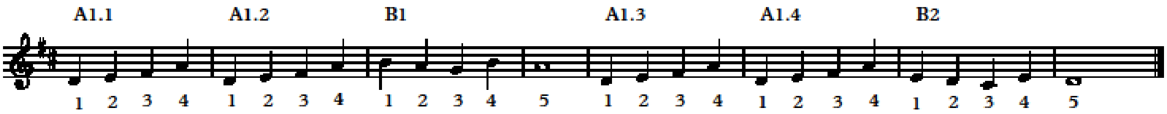


Figure 4.4. Experimental stimulus.

4.4.1 Age category 1: TD children aged 6-8

4.4.1.1 Phrase A first trial

Phrase A is repeated four times in each trial (A1.1, A1.2, A1.3, and A1.4), and consists of two ascending major 2^{nd} intervals and one ascending major 3^{rd} interval. Figure 4.5 and Table 4.23, below, depict 6-8-year-olds' mean expectancy ratings for trial 1.

- The first analysable pitch interval is the major 2^{nd} from pitches 2-3 in A1.1, which accords with an increase in expectedness (Table 4.23 trial 1: A1.1, pitches 2-3).
- The subsequent interval of a major 3^{rd} continues the melodic direction but is perceived as unexpected (see the 6-point decrease in ratings in Table 4.23 trial 1, phrase A1.1 pitches 3-4).
- Phrase A1.2 generates a similar set of responses, whereby pitches 1-2 and 2-3 (both a major 2^{nd}) increase in expectedness, and the major 3^{rd} between pitches 3-4 decreases by 1 point.

- A1.3 is presented after phrase B, where the same response pattern resumes except for pitches 2-3 in A1.3 (a major 2nd) which decreases in expectedness by 3 points.
- Similarly, each major 2nd in A1.4 is rated as expected (trial 1: phrase A1.4, pitches 1-2 and 2-3), and the major 3rd is perceived as surprising (see the 11-point decrease from pitches 3-4 in A1.4).

These results reveal that 6-8-year-olds' ratings are consistent for phrase A in the first trial. Each major 2nd increases in expectedness (except for one interval in A1.3), and each major 3rd decreases in expectedness. The consistency of ratings indicates evidence of long-term schematic expectations. Additionally, the consistent surprise in response to the major 3rd could be representative of perceived pattern disruption, implying the presence of within-group expectations. The ensuing analysis of repeated trials may clarify the distinction between schematic and within-group expectations. There is no orderly change in the degree of predictability, and thus no evidence of a change in veridical expectations.

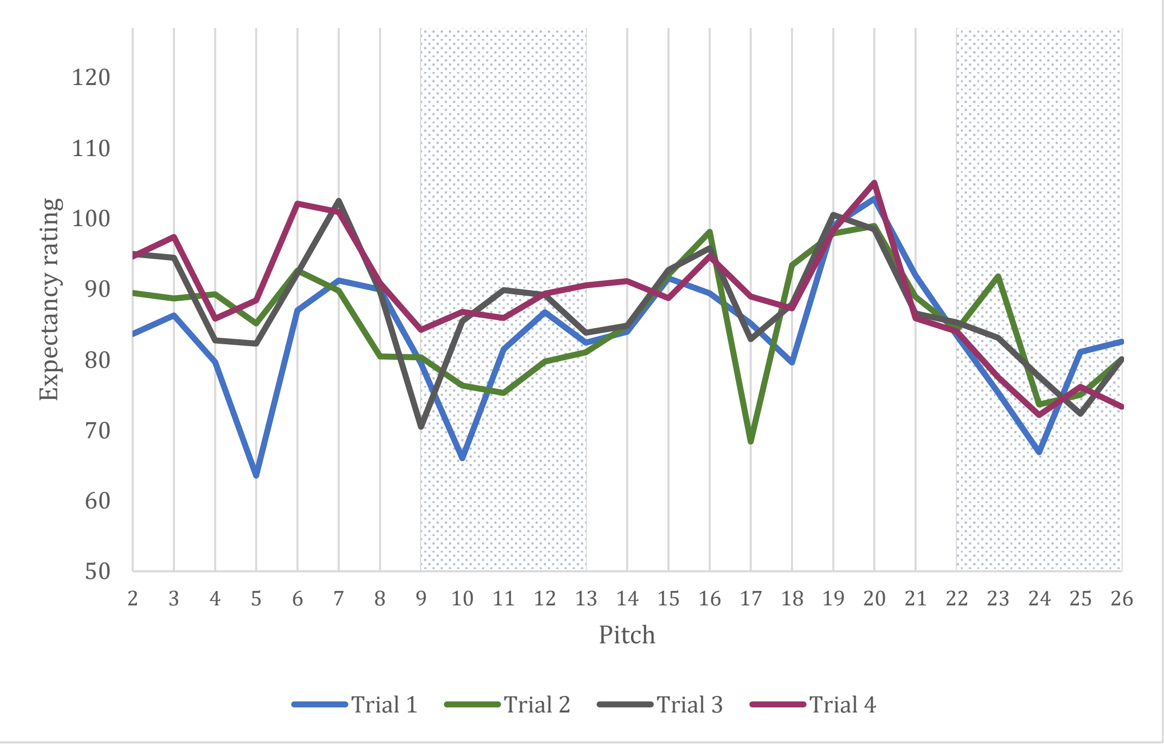


Figure 4.5. TD children aged 6-8. Pitch by pitch expectancy rating for trials 1-4 in session 1. Shaded sections signify phrase B.

Table 4.23. TD children aged 6-8. Mean pitch by pitch expectancy rating for trials 1-4 in session 1.

Phrase	A1.1			A1.2				B1					A1.3				A1.4				B2				
Pitch	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Trial 1	84	86	80	64	87	91	90	79	66	81	87	82	84	92	89	85	80	99	103	92	83	75	67	81	83
Trial 2	89	89	89	85	93	90	80	80	76	75	80	81	85	92	98	68	93	98	99	89	84	92	74	75	80
Trial 3	95	94	83	82	92	103	90	70	85	90	89	84	85	93	96	83	88	101	99	87	85	83	78	72	80
Trial 4	95	97	86	88	102	101	91	84	87	86	89	91	91	89	95	89	87	98	105	86	84	78	72	76	73

4.4.1.2 Phrase A repeated trials

The remaining trials follow a similar response pattern to that described in trial 1, where each major 2nd increases in expectedness, and each major 3rd decreases in expectedness. Key points are highlighted below:

- In trial 2, children exhibit irregular responses for phrases A1.1 and A1.2 (see Table 4.23, trial 2, pitches 2-4 A1.1 and 1-4 A1.2), however, ratings for A1.3 and A1.4 follow the established response pattern.
- Ratings for trials 3 and 4 generally follow the established pattern. There are two exceptions in trial 3 (phrase A 1.1 pitches 2-3, phrase A1.4 pitches 2-3) and one exception in trial 4 (phrase A1.2 pitches 2-3) where the major 2nd slightly decreases in expectedness.
- The rating trends are similar in session 2, notwithstanding two occasions in each of trials 5 and 6, and one occasion in each of trials 7 and 8.

These results show that the majority of 6-8-year-olds' ratings for phrase A follow an established pattern, indicating an influence of long-term memory schemas and supporting the notion that schematic expectations are active. Participants are consistently surprised by the major 3rd which could indicate that within-group expectations are in operation. On the other hand, participants may be exhibiting an heuristic for an adjacency effect as noted in Thorpe et al., (2012) whereby the smaller the interval between pitches, the stronger the expectation (Ortman, 1926, Huron, 2006). Considering the age of this group, the adjacency heuristic may be the most likely explanation as it can pertain to two pitches, and does not require listeners to retain melodic information in working memory for several pitches. Furthermore, the degree of predictability does not alter as a function of repetition, thus veridical expectations are not thought to be influential. This concurs with visual inspection of Figures 4.5 and 4.6, whereby ratings are occasionally separated in order of trial, but are more often clustered together.

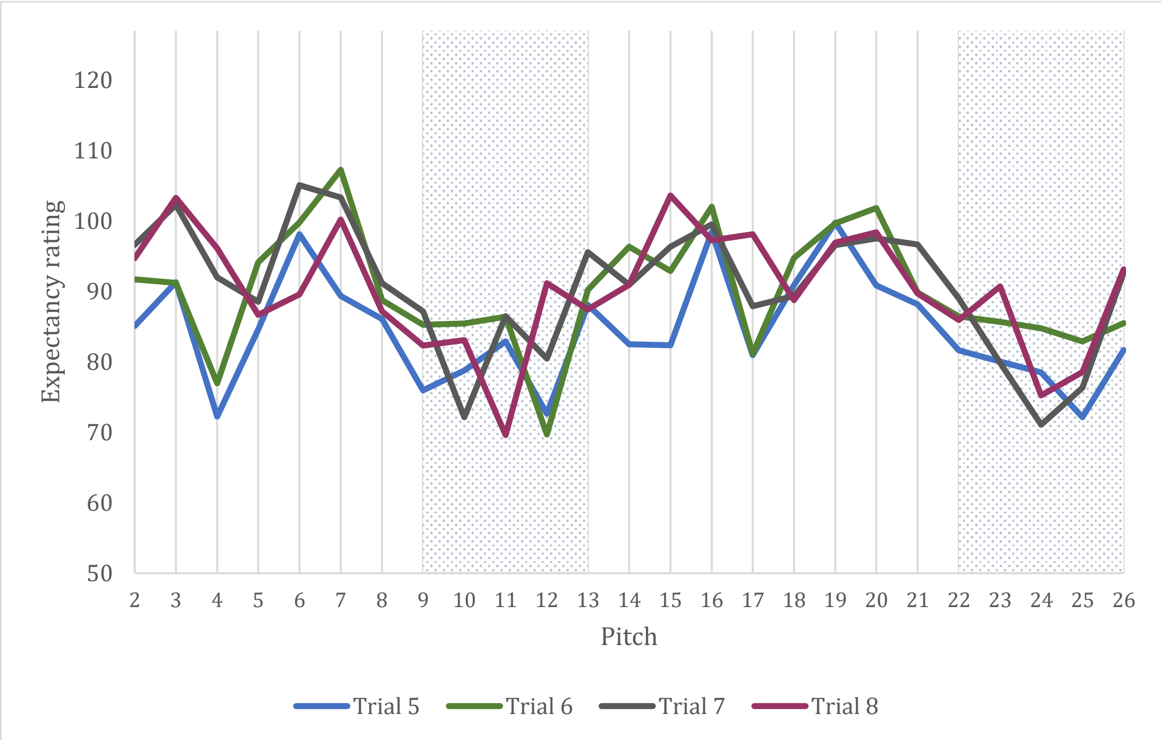


Figure 4.6. TD children aged 6-8. Pitch by pitch expectancy rating for trials 5-8 in session 2. Shaded sections signify phrase B.

Table 4.24. TD children aged 6-8. Mean pitch by pitch expectancy rating for trials 5-6 in session 2.

Phrase	A1.1			A1.2				B1					A1.3				A1.4				B2				
Pitch	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Trial 5	85	91	72	85	98	89	86	76	79	83	73	88	83	82	98	81	91	100	91	88	82	80	78	72	82
Trial 6	92	91	77	94	100	107	89	85	85	86	70	90	96	93	102	81	95	100	102	90	86	86	85	83	85
Trial 7	97	102	92	89	105	103	91	87	72	87	80	96	91	96	100	88	89	97	98	97	89	80	71	76	93
Trial 8	95	103	96	87	90	100	87	82	83	70	91	87	91	104	97	98	89	97	98	90	86	91	75	79	93

4.4.1.3 Phrase B first trial

Phrase B is heard twice in each trial (B1 and B2) and comprises two consecutive descending major 2nd intervals, followed by two major 3rd intervals that each change the melody's direction (Figure 4.4). Additionally, B2 is transposed a fifth lower than B1.

- Ratings for phrase B1 are consistent with the hypothesis that listeners expect a melodic pattern to continue between pitches 2-3 in B1 (Table 4.23 trial 1, phrase B1, pitches 2-3), but is inconsistent with the hypothesis that a change in pitch direction violates expectations and is therefore surprising (Table 4.23, trial 1, phrase B1, pitches 3-4).
- On the other hand, ratings for phrase B2 are inconsistent with the notion that listeners expect a melodic pattern to continue (Table 4.23, trial 1, phrase B1, pitches 2-3) and also inconsistent with the hypothesis that a change in direction is surprising (Table 4.23, trial 1, phrase B2, pitches 3-4).
- The low rating at pitch 3 in B2 is replicated in the adults' ratings for trial 1 and thus will be monitored during analysis of trials 2-7.

These results reveal inconsistent ratings, indicating that 6-8-year-olds' perception of phrase B is not yet underpinned by reliable expectations. This is possibly due to the more complex patterning of phrase B that comprises more changes in direction, requiring listeners to engage with several pitches along a continuum in order to fully assimilate the phrase.

4.4.1.4 Phrase B repeated trials

Ratings in response to trials 2, 3, and 4 continue to appear random, implying that 6-8-year-olds are not generating reliable expectations. During session 2, rating patterns become more consistent, as highlighted below.

- Melodic pattern continuation between pitches 2-3 in B1 is rated as expected in trials 5-7, and the ensuing change in direction (pitches 3-4 in B1) is rated as unexpected in trials 5-8. These consistent ratings show evidence of schematic expectations which may have emerged as a result of trial repetition. It is not clear as to whether the consistent ratings have occurred as a result of pattern continuation (within-group expectations), or an adjacency effect (schematic expectations).
- The phrase endings between pitches 4-5 in phrase B1 and 4-5 in phrase B2 are consistently perceived as expected in all but one occurrence, representing a schematic expectation for tonal stability that is influenced by closure.
- Interestingly, pitch 3 in phrase B2 continues a descending pattern of major 2nd intervals, however, it is consistently perceived as surprising in all trials. The likelihood of whether this is influenced by the mean distribution of pitch (see section 3.2.3 chapter 3) or due to contour imitation will be discussed in chapter 7.

These results show that 6-8-year-olds perceive phrase B as more complex than phrase A, whereby evidence of consistent expectations does not appear until the second session. It is not clear as to whether the consistent ratings are a result of schematic expectations for adjacent pitches/pitch proximity, or within-group expectations for pattern continuation. However, considering the participants' young age it is probable that the schematic expectation for adjacency is more influential as it can operate in response to two pitches. The consistently low rating for pitch 3 in B2 could be related to Stalinski and Schellenberg's finding (2010) that younger children attend more closely to surface features of melody, and therefore may be explained as an influence of contour or low melodic range. The degree of predictability does not change as a function of repetition, which supports the notion that veridical expectations are not influential. However, considering the young age of this group, task comprehension, attention, and methodological influences may have an additional influence.

4.1.1.5 Whole melody: rating distribution

Investigating trial by trial changes in the rating distribution highlights the functioning of veridical expectations. It is expected that the spread of ratings would decrease as veridical expectations become more dominant and perceived expectedness peaks. Table 4.25 presents the difference in mean ratings between each pitch, aggregated by trial. The mean tends to decrease throughout session 1 and to increase again between sessions, however, there is little change during session 2. This result can be combined with a second method which measures the lag1 autocorrelation between each pair of pitches. The higher the autocorrelation coefficient's value (*ø*), the stronger the correlation and the smaller the rating distribution (see Tables 4.26 and 4.27). As Table 4.27 shows, the progression from non-significance in trials 1 and 2 to significance in trials 3-8 suggests that the regularity of rating patterns increase with each stimulus repetition. There are no significant differences between the sessions or trials, indicating that the level of variance is similar throughout the experiment.

Table 4.25. TD children aged 6-8. Mean differences between pitches, split by trial.

Session	Trial	Mean
Session 1	Trial 1	8.302
	Trial 2	6.681
	Trial 3	7.034
	Trial 4	5.426
Session 2	Trial 5	8.382
	Trial 6	7.799
	Trial 7	7.793
	Trial 8	7.884

Table 4.26. TD children aged 6-8. Autocorrelation coefficient (ø) for sessions 1 and 2.

Session	Intercept	*p value*	ϕ	*p value*	Std D
Session 1	86.356	0.000***	0.142	0.000***	2.624
Session 2	89.302	0.000***	0.167	0.000***	3.393

*p < .05. **p < .01. ***p < .001.

Table 4.27. TD children aged 6-8. Autocorrelation coefficient (ø) for trials 1-8.

Session	Trial	Intercept	*p value*	ϕ	*p value*	Std D
Session 1	Trial 1	83.772	0.000***	0.08	0.101	2.877
	Trial 2	85.741	0.000***	0.113	0.044	3.452
	Trial 3	87.096	0.000***	0.151	0.009**	3.089
	Trial 4	88.602	0.000***	0.254	0.000***	3.696
Session 2	Trial 5	85.486	0.000***	0.116	0.049*	3.595
	Trial 6	90.878	0.000***	0.197	0.006**	3.991
	Trial 7	91.719	0.000***	0.244	0.001**	3.652
	Trial 8	90.299	0.000***	0.188	0.008**	4.156

*p < .05. **p < .01. ***p < .001.

4.4.2 Age category 2: TD children aged 9-12

4.4.2.1 Phrase A first trial

Pitch-level analyses of expectancy ratings provided by children aged 9-12 replicate the previously outlined response pattern whereby in the case of phrase A, each major 2nd tends to be rated as expected and each major 3rd tends to be rated as surprising. Ratings for phrase A1.1 and A1.3 are consistent with the identified response pattern with no discrepancies. Three exceptions are noted below:

- The major 3rd between pitches 3-2 in phrase A1.2 generates a 1-point increase in expectedness (see Table 4.28, trial 1).

- The major 2nd that occurs between pitches 2-3 in phrase A1.4 generates a decrease in expectedness, and the major 3rd between pitches 3-4 in phrase A1.4 increases in expectedness.

These results indicate that melodic expectations for phrase A are consistent throughout the first trial, although as noted above, the distinction between schematic and within-group expectations is still unclear. The degree of predictability does not change in response to repetition, indicating that there is no cumulative effect of repetition during the first trial.

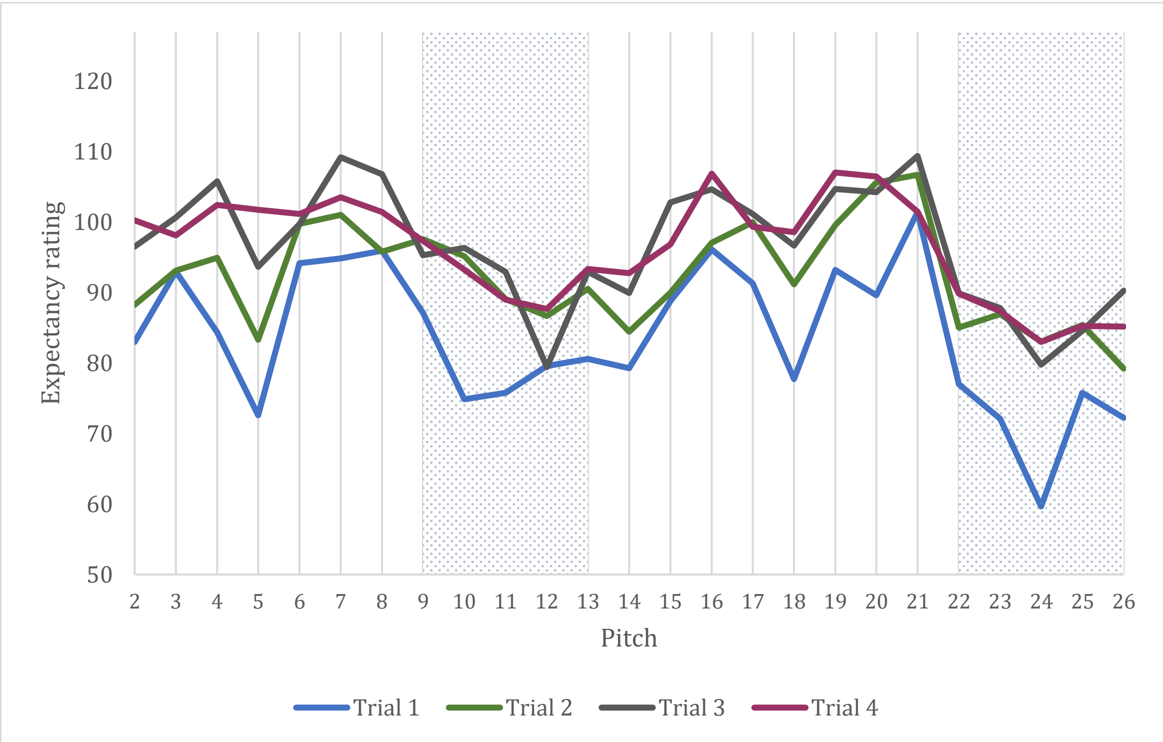


Figure 4.7. TD children aged 9-12. Pitch by pitch expectancy rating for trials 1-4 in session 1. Shaded sections signify phrase B.

Table 4.28. TD children aged 9-12. Mean pitch by pitch expectancy rating for trials 1-4 in session 1.

Phrase	A1.1			A1.2				B1					A1.3				A1.4				B2				
Pitch	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Trial 1	83	93	84	73	94	95	96	87	75	76	80	81	79	89	96	91	78	93	90	101	77	72	60	76	72
Trial 2	88	93	95	83	100	101	96	98	95	89	87	91	84	90	97	100	91	100	106	107	85	87	83	85	79
Trial 3	97	101	106	94	100	109	107	95	96	93	79	93	90	103	105	101	97	105	104	109	90	88	80	85	90
Trial 4	100	98	102	102	101	104	101	97	93	89	88	93	93	97	107	99	99	107	106	101	90	87	83	85	85

4.4.2.2 Phrase A repeated trials

The remaining trials in sessions 1 and 2 reveal that on the whole, 9-12-year-olds' ratings are consistent except for ratings in response to the major 3rd in session 1. Furthermore, there is a systematic increase in overall expectedness as each trial unfolds.

- In session 1, each major 2nd is rated as predictable except for two slight decreases in expectedness (pitches 2-3 in A1.4 in trials 3 and 4, see Table 4.28).
- Throughout the second session, each major 2nd is perceived as predictable except for pitches 2-3 in A1.2 in trials 5 and 6, and pitches 2-3 in A1.1 in trial 8 (see Table 4.29).
- During session 1, the major 3rd generates irregular ratings. For example, in trial 2, the major 3rd in A1.1, A1.3 and A1.4 is regarded as expected. This is also the case during phrase A1.1 and A1.4 in trials 3 and 4.
- During session 2, ratings for the major 3rd in trials 5-8 are rated as surprising in all cases except for two occasions (pitches 3-4 in A1.1 and 3-4 in A13 in trial 8).

These results show that 9-12-year-olds' melodic expectations are consistent with an established rating pattern which continues throughout all trials, indicating that schematic expectations are present for phrase A. Again, within-group expectations may also be present, as demonstrated by the possibility of an expectation for pattern continuation, although it is difficult to separate this from the schematic expectation for adjacency. It could be the case that the inconsistencies exhibited by the major 3rd during session 1 may be due to various intermittent perceptual influences such melodic contour, pitch proximity, and within-group projections, none of which are most dominant. Such ideas can be explored in the discussion chapter. Veridical expectations also appear to be weakly influential as shown by the increase in overall expectedness from trials 1-4 and session 1

(Figure 4.7) and trials 5-8 in session 2 (Figure 4.8). This is to be addressed in the upcoming whole melody analysis (section 4.4.2.5).

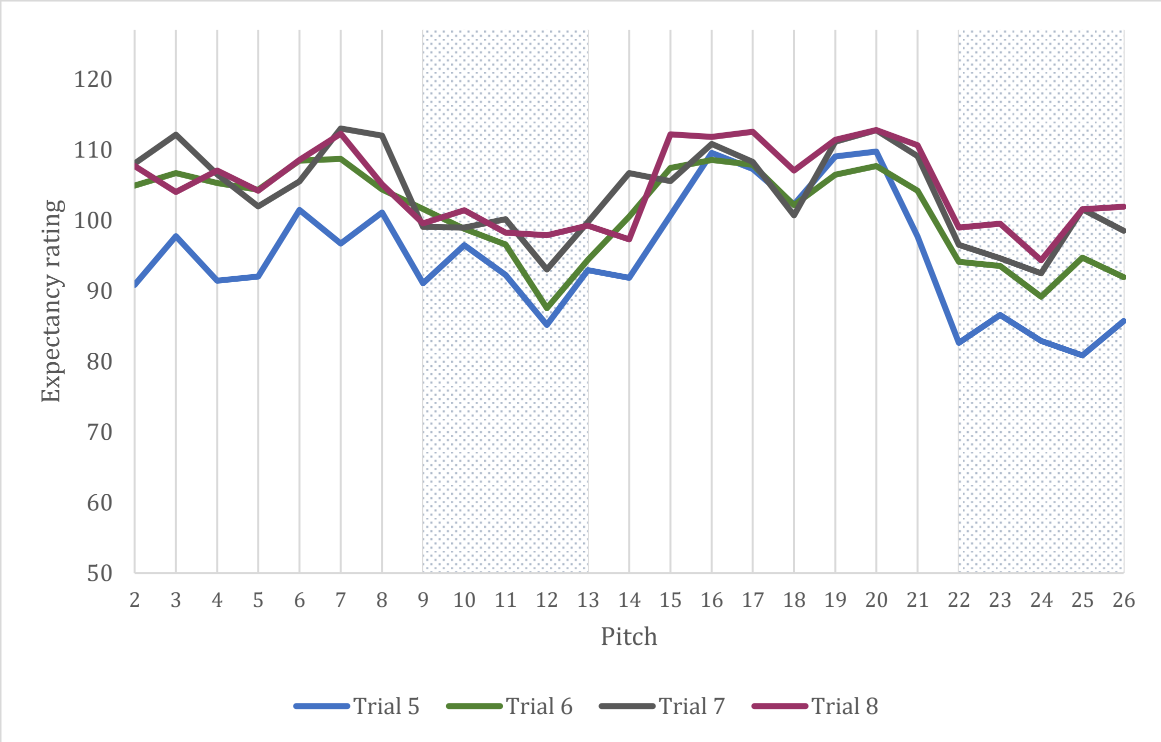


Figure 4.8. TD children aged 9-12. Pitch by pitch expectancy rating for trials 5-6 in session 2. Shaded sections signify phrase B.

Table 4.28. TD children aged 9-12. Mean pitch by pitch expectancy rating for trials 5-8 in session 2.

Phrase	A1.1			A1.2				B1					A1.3				A1.4				B2				
Pitch	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Trial 5	91	98	91	92	101	97	101	91	96	92	85	93	92	101	110	107	102	109	110	98	83	87	83	81	86
Trial 6	105	107	105	104	108	109	104	102	99	97	88	94	101	107	109	108	102	106	108	104	94	94	89	95	92
Trial 7	108	112	107	102	106	113	112	99	99	100	93	100	107	106	111	108	101	111	113	109	97	95	92	102	99
Trial 8	108	104	107	104	109	112	105	100	101	98	98	99	97	112	112	113	107	111	113	111	99	100	94	102	102

4.4.2.3 Phrase B first trial

Results for phrases B1 and B2 in the trial 1 do not present any evidence of schematic, within-group or veridical expectations, as noted below.

- Ratings for phrase B1 in the first trial initially suggest that pattern continuation (within-groups) leads to a sense of expectedness (Table 4.28, trial 1, phrase B1, pitches 2-3), but this is disputed considering that the following change in direction (pitches 2-3 B1) is also rated as expected.

- Phrase B2 generates different ratings compared with phrase B1 whereby the melodic pattern continuation between pitches 2-3 in B2 (parallel with B1) is rated as surprising.
- Similarly to 6-8-year-olds and adults, pitch 3 in B2 generates a particularly low rating, possibly influenced by melodic contour or range.

It is suggested that perception of phrase B in the first trial may be driven by surface features of melody rather than expectations based on statistical learning or Gestalt principles.

4.4.2.4 Phrase B repeated trials

The remaining trials generate consistent ratings in response to B1, which are distinct from the consistent ratings in response to B2. Key examples are outlined below:

- During trials 2-4 (unlike trial 1), all melodic pattern continuations between pitches 2-3 in B1 for phrase B1 are regarded as unexpected (see Table 4.28). The same is true for pitches 2-3 in phrase B2. This suggests that participants' expectations are dominated by the descending melodic contour rather than pattern continuation.
- In contrast to the first trial, the change in direction between pitches 3-4 in B1 during the remaining trials in session 1 is consistently rated as surprising, which could represent within-group expectations and/or adjacency. Conversely, the same change in direction that occurs in response to phrase B2 (pitches 3-4 in B2) is rated as expected for trials 2, 3, and 4, which suggests either imitation of melodic contour, or a schematic expectation for melodic closure that is driven by tonal stability.

- Additionally, the final interval between pitches 4-5 in phrase B1 is consistently rated as expected, indicating that the schematic expectation for melodic closure is a dominant influence. Interestingly the final interval in phrase B2 (pitches 4-5) is not consistent, which implies that the low register is a dominant melodic feature.
- During all trials in session 2 (excluding trial 7), pitches 2-3 in B1 are again rated as surprising, indicating that the descending melodic contour is a dominant influence, rather than pitch relationships.
- The following change in direction between pitches 3-4 in B1 is rated as surprising in trials 5, 6, and 7, which suggests an influence of within-group expectations or adjacency that persist despite stimulus repetition. The following interval in phrase B1 (pitches 4-5) is consistently rated as expected, which indicates a strong influence of tonal stability and melodic closure.
- On the contrary, phrase B2 reveals different ratings, whereby the interval between pitches 3-4 in B2 is rated as expected during trials 6, 7, and 8, demonstrating either imitation of melodic contour, or a schematic expectation for tonally stable closure. Ratings for the final interval (pitches 4-5 in B2) are inconsistent, implying that the expectation for closure is dominated by the low register of B2.

Ratings for phrase B indicate that melodic perception of 9-12-year-olds is more developed than 6-8-year-olds. Most striking is the difference in ratings between phrases B1 and B2. For example, B1 is consistently influenced by an expectation for schematic and/or within-group expectations throughout both sessions, whereas ratings for B2 are more strongly influenced by melodic range and also perhaps temporal location. These results show that participants are absorbing global information about the melody, whereby the low register becomes prominent in comparison to the mid-register at which the rest of the melody occurs. This key finding demonstrates developmental progression whereby 9-12-year-olds are attending to groups of pitches occurring on a longer temporal trajectory than 6-8-year-olds. Again, veridical expectations are yet to have an observable influence on ratings for phrase B, and instead, expectations are dominated by sensory, schema- and Gestalt-driven processes.

4.4.2.5 Whole melody: rating distribution

Visual observation of Figures 4.7 and 4.8 reveals an increase in overall expectedness throughout each session together with a flattening contour, indicating that the expectations of 9-12-year-olds change in response to stimulus repetition. Table 4.30 presents the mean difference between pitches aggregated by trial, showing an overall but non-linear reduction in the dispersion of ratings. The autocorrelation coefficients are displayed in Table 4.31, suggesting that successive pitches in session 2 are more strongly correlated to each other compared to successive pitches in session 1, although there are no significant differences between the sessions. Furthermore, Table 4.32 shows that the overall expectedness increases (indicated by the increasing intercept). Again, there are no significant differences between the trials.

Table 4.30. TD children aged 9-12. Mean differences between pitches, split by trial.

Session	Trial	Mean
Session 1	Trial 1	8.725
	Trial 2	5.824
	Trial 3	6.742
	Trial 4	3.728
Session 2	Trial 5	5.923
	Trial 6	3.724
	Trial 7	5.100
	Trial 8	3.890

Table 4.31. TD children aged 9-12. Autocorrelation coefficients (ø) for sessions 1 and 2.

Session	Intercept	*p value*	ϕ	*p value*	Std D
Session 1	92.565	0.000***	0.402	0.000***	2.663
Session 2	101.624	0.000***	0.469	0.000***	3.066

*p < .05. **p < .01. ***p < .001.

Table 4.32. TD children aged 9-12. Autocorrelation coefficients (ø) for trials 1-8.

Session	Trial	Intercept	*p value*	ϕ	*p value*	Std D
Session 1	Trial 1	83.112	0.000***	0.321	0.000***	2.83
	Trial 2	92.114	0.000***	0.349	0.000***	3.206
	Trial 3	95.64	0.000***	0.41	0.000***	3.361
	Trial 4	95.904	0.000***	0.524	0.000***	3.756
Session 2	Trial 5	95.148	0.000***	0.488	0.000***	3.549
	Trial 6	99.987	0.000***	0.513	0.000***	3.977
	Trial 7	104.627	0.000***	0.499	0.000***	3.93
	Trial 8	106.397	0.000***	0.496	0.000***	3.858

4.4.3 Age category 3: TD children aged 13-17

4.4.3.1 Phrase A: first trial

The melodic expectancy ratings of 13-17-year-olds mirror the response pattern set out for phrase A (whereby each major 2nd is rated as expected, and each major 3rd is rated as unexpected) with greater consistency than seen in the two younger age groups. Key results from trial 1 are highlighted below:

- The established rating pattern for phrase A is disrupted once in trial 1; the major 3rd between pitches 3-4 in phrase A1.2 is rated as expected.
- Participants consistently rate the major 3rd as surprising, and this occurs to a lessening degree as the trial unfolds e.g. from phrase A1.1 (a 16-point decrease)

to A1.3 (a 9-point decrease) to A1.4 (a 1-point decrease). This implies that expectations are affected by phrase repetition.

Ratings for phrase A in trial 1 are more consistent in this age group compared with younger participants. Additionally, there is a cumulative effect of phrase repetition that was not identified in younger children. Both of these findings point to a developmental shift in melodic perception that appears in early adolescence.

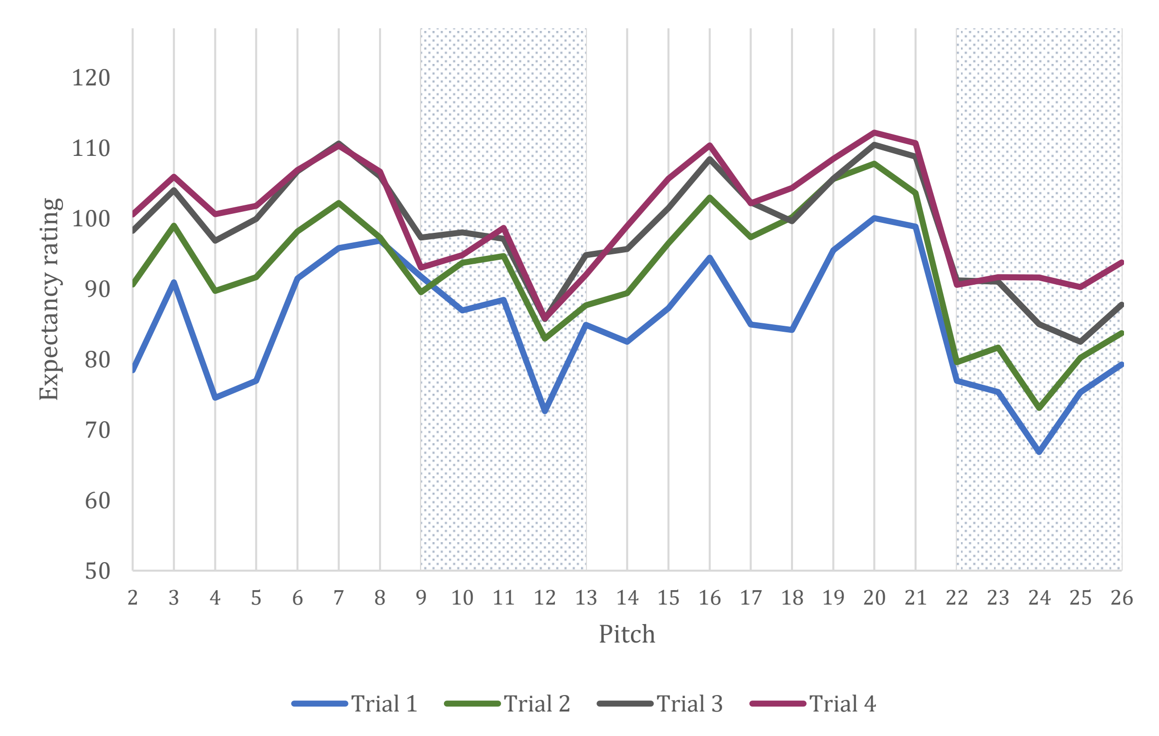


Figure 4.9. TD children aged 13-17. Pitch-level expectancy ratings for trials 1-4 in session 1. Shaded sections signify phrase B.

Table 4.33. TD children aged 13-17. Pitch-level expectancy ratings for trials 1-4 in session 1.

Phrase	A1.1			A1.2				B1					A1.3				A1.4				B2				
Pitch	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Trial 1	78	91	75	77	91	96	97	92	87	88	73	85	83	87	94	85	84	95	100	99	77	75	67	75	79
Trial 2	91	99	90	92	98	102	97	90	94	95	83	88	89	96	103	97	100	106	108	104	80	82	73	80	84
Trial 3	98	104	97	100	107	111	106	97	98	97	86	95	96	101	108	102	100	106	110	109	91	91	85	82	88
Trial 4	101	106	101	102	107	110	107	93	95	99	86	92	99	106	110	102	104	108	112	111	91	92	92	90	94

4.4.3.2 Phrase A: repeated trials

13-17-year-olds' ratings for phrase A continue to consistently follow the established response pattern throughout the remaining trials in sessions 1 and 2, indicating that expectations stem from a reliable source rooted in long-term memory. Furthermore, evidence of a cumulative influence of repetition is apparent throughout all trials. For example:

- The unexpectedness in response to the major 3rd steadily decreases in size between A1.1 and A1.2, and between A1.3 and A1.4 across all trials (as can be seen in Figures 4.9 and 4.10, and Tables 4.33 and 4.34).

As indicated in the results for trial 1, ratings provided in trials 2-8 show that a change in melodic perception occurs as children reach the age bracket of 13-17. For example, in addition to a consistent pattern of expectedness, the cumulative influence of phrase and stimulus repetition demonstrates that veridical expectations occur between phrases and trials which is not identified in younger age groups. Furthermore, veridical expectations are also affected by *recency* of the repetition whereby the degree of surprise between A1.1 and A1.2 is reset after the presentation of phrase B, although the extent to which this occurs does not follow a pattern from trial to trial. This is also discussed in the whole melody analysis (section 4.4.4.5) which compares the spread of ratings between each trial. Despite the consistent influence of repetition, participants continue to rate the major 3rd as unexpected, implying that expectations rooted in long-term memory such as within-group expectations (expectations for pattern continuation) and schematic expectations (adjacency effect) are not completely dominated by veridical expectations.

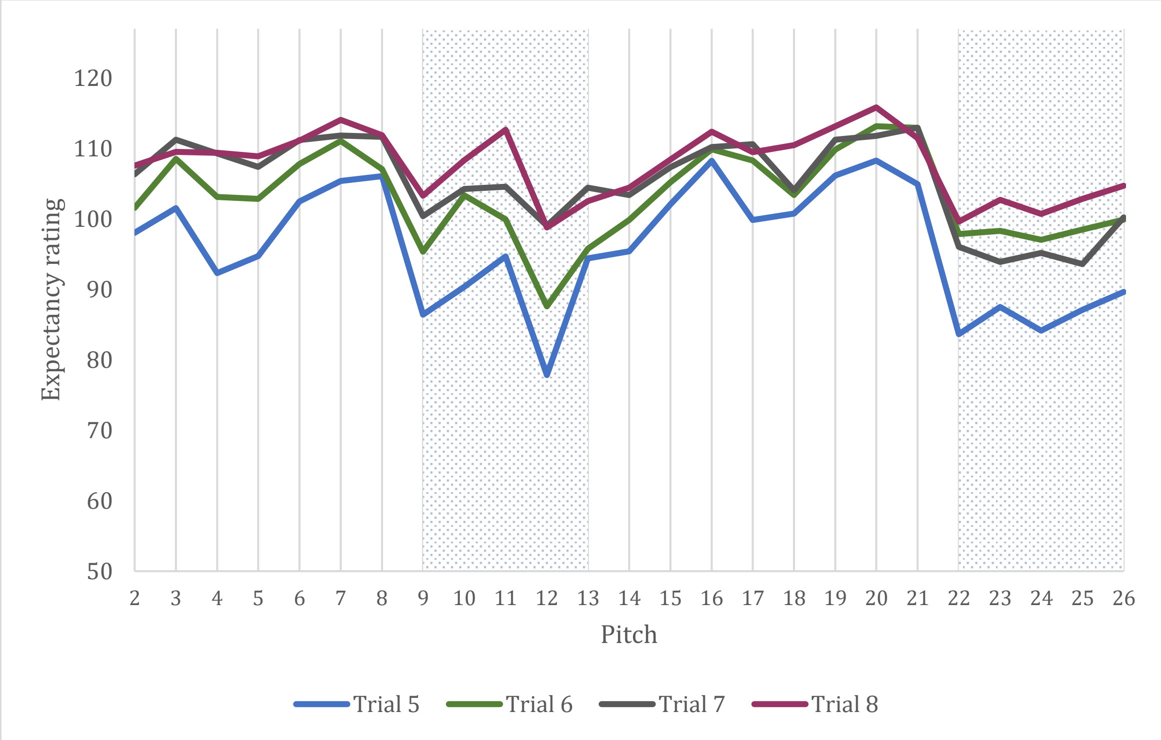


Figure 4.10. TD children aged 13-17. Pitch-level expectancy ratings for trials 5-8 in session 2. Shaded sections signify phrase B.

Table 4.34. TD children aged 13-17. Pitch-level expectancy ratings for trials 5-8 in session 2.

Phrase	A1.1			A1.2				B1					A1.3				A1.4				B2				
Pitch	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Trial 5	98	102	92	95	103	105	106	86	90	95	78	94	95	102	108	100	101	106	108	105	84	88	84	87	90
Trial 6	102	109	103	103	108	111	107	95	103	100	88	96	100	105	110	108	103	110	113	113	98	98	97	99	100
Trial 7	106	111	109	107	111	112	112	100	104	105	99	104	103	107	110	111	104	111	112	113	96	94	95	94	100
Trial 8	108	110	109	109	111	114	112	103	108	113	99	103	104	108	112	109	111	113	116	111	100	103	101	103	105

4.4.3.3 Phrase B: first trial

Ratings for phrase B1 reveal expectations that coordinate with complex melodic principles. On the contrary, ratings for B2 are influenced by surface features. Examples are highlighted below:

- In phrase B1, pitches 2-3 continue a descending pattern of 2-semitone intervals and is rated as expected, followed by a change in direction from pitches 3-4 which is perceived as surprising. Thereafter, the melody changes direction and closes the phrase on the dominant scale degree, which is rated as expected.

- The three key findings in the above bullet point indicate that participants are exhibiting expectations for phrase B1 based on varying sources. For example, the predictability of pitches 2-3 could be based on a schematic expectation for adjacency and/or an expectation for pattern continuation. The surprise at the change in direction from pitches 3-4 could imply disrupted within-group expectations and/or influence of adjacency (a major 3rd). Finally, the expectedness of phrase closure on the dominant is suggestive of schematic expectations for tonal stability.
- On the other hand, phrase B2 is transposed a 5th lower than B1, and reveals a difference in ratings. Most notably, pitch 3 in B2 is the lowest pitch in the melody and is rated as surprising, implying that prominent surface features such as pitch frequency are influential.

The difference between phrase B1 and B2 is indicative of a dynamic set of expectations that depends on melodic context. It is implied that although schematic and within-group expectations are present, prominent surface features such as pitch frequency are also influential. However, it is recognised that the rating paradigm may lead to imitation of the melodic contour, although if this is the case, it is not supported by any consistency – for example, the melody's final interval decreases in pitch, but the participants' ratings increase in expectedness.

4.4.3.4 Phrase B: repeated trials

Phrases B1 and B2 are rated by 13-17-year-olds as distinct from each other throughout trials 2-8. As observed in trial 1, ratings for phrase B1 are underpinned by complex melodic features such as within-group pattern continuation, whereas simpler functions are prominent in response to phrase B2. Examples are noted below:

- During all trials expect for 3 and 6, the pattern continuation between pitches 2-3 in phrase B1 generates an increase in expectedness, and the change in direction between pitches 3-4 in B1 is consistently surprising in all trials. This replicates the results for trial 1, indicating that expectations for B1 are informed by a schematic expectation for adjacency and/or an expectation for pattern continuation, and additionally demonstrates that expectations are robust in response to trial repetition.
- Throughout all trials except for 4 and 7, ratings for phrase B2 reveal that participants are continually surprised by pitches 2-3 in B2 despite the opposite ratings for the same interval in B1. Again, this replicates 13-17-year-olds' ratings for phrase B2 in trial 1. As this result is consistent throughout all trials, it is less indicative of contour imitation, and instead implies a dynamic flux of expectations whereby salient surface features become a dominant influence even when the stimulus repeats.
- A further indication of developed melodic understanding for this age group is demonstrated by the consistent increase in expectedness for the final interval in phrases B1 and B2, which was not evident in the younger age groups. This shows schematic expectations for tonal stability at phrase endings that are underpinned by global melodic perception.

The ratings of 13-17-year-olds in response to phrase B reveal that each phrase generates a distinct pattern of expectation that persists in response to stimulus repetition, both of which are informed by groups of notes comprising three or more pitches, indicating the assimilation of complex melodic information. Additionally, 13-17-year-olds show dominant schematic expectations for tonal stability at phrase endings, which indicates a developmental change in melodic perception compared with 9-12-year-olds. These results demonstrate that the expectations of this age group are dynamic and interchangeable depending on the current melodic context, but these fluctuations are consistent across an indefinite number of exposures to the same melody.

4.4.3.5 Whole melody: rating distribution

Figures 4.9 and 4.10 display an increase in expectedness for each trial repetition alongside a flattening contour. The mean difference between pitches is displayed in Table 4.35, which shows a linear decrease throughout each session, indicating a cumulative influence of stimulus repetition. However, Tables 4.36 and 4.37 show autocorrelation coefficients that tend to increase with repetition although there are no significant differences between the trials, indicating that the variance is consistent throughout the experiment.

Table 4.35. TD children aged 13-17. Mean differences between pitches, split by trial.

Session	Trial	Mean
Session 1	Trial 1	7.364
	Trial 2	6.044
	Trial 3	5.367
	Trial 4	5.275
Session 2	Trial 5	6.493
	Trial 6	4.949
	Trial 7	3.825
	Trial 8	3.754

Table 4.36. TD children aged 13-17. Autocorrelation coefficients (ø) for sessions 1 and 2.

Session	Intercept	*p value*	ϕ	*p value*	Std D
Session 1	94.216	0.000***	0.454	0.000***	2.219
Session 2	102.652	0.000***	0.516	0.000***	2.322

*p < .05. **p < .01. ***p < .001.

Table 4.37. TD children aged 13-17. Autocorrelation coefficients (*ø*) for trials 1-8.

Session	Trial	Intercept	*p value*	ϕ	*p value*	Std D
Session 1	Trial 1	84.949	0.000***	0.387	0.000***	2.646
	Trial 2	91.609	0.000***	0.448	0.000***	2.517
	Trial 3	98	0.000***	0.461	0.000***	2.816
	Trial 4	99.372	0.000***	0.497	0.000***	2.885
Session 2	Trial 5	95.123	0.000***	0.454	0.000***	2.643
	Trial 6	102.716	0.000***	0.479	0.056	2.662
	Trial 7	104.064	0.000***	0.567	0.000***	3.018
	Trial 8	107.349	0.000***	0.563	0.000***	2.86

*p < .05. **p < .01. ***p < .001.

4.5 Analysis of questionnaire items

A succession of multiple linear regressions were conducted so that the potential influence of participants' music listening and playing experiences could be explored. The independent variables were a) age b) gender; c) months of formal musical training; and d) minutes spent listening to music per week. Gender was categorised as a dummy variable coded 0 for females and 1 for males, and the other three variables were categorised as continuous. As noted in chapter 3, regression was selected due to the wide age range of participants and thus the wide range of instrumental training. A multiple regression was performed for each of the following pitch combinations:

- All 200 pitches in session 1 (model 1)
- All 200 pitches in session 2 (model 2)
- Phrase A 60 pitches in session 1 (model 3)
- Phrase A 60 pitches in session 2 (model 4)
- Phrase B 40 pitches in session 1 (model 5)
- Phrase B 40 pitches in session 2 (model 6)

As depicted in Tables 4.38, 4.39, and 4.40, the results reveal that gender, formal music training and weekly minutes of music listening are not significant predictors for participants' performance on the rating task. Age, however, is a significant predictor during the second session for the whole melody and phrase A. The *p* value for age in relation to phrase B session 2 is also approaching significance (p = 0.051). These results suggest that sensitivity to repetition is influenced by age, but that time spent listening to music and months of music training do not predict children's melodic expectations in this study.

Table 4.38. Whole melody. Multiple regression model 1 (session 1) and model 2 (session 2) for TD children.

	Session 1 - whole melody				**Session 2 - whole melody**			
Variable	***B***	***SE***	***β***	***p* value**	***B***	***SE***	***β***	***p* value**
Constant	80.74	5.61		0.000	78.627	6.29		0.000
Age	0.714	0.537	0.132	0.186	1.389	0.606	0.224	0.023*
Gender	2.211	2.701	0.066	0.414	2.599	3.003	0.069	0.388
Months training	-0.001	0.043	-0.003	0.976	0.039	0.048	0.072	0.426
Mins listening	0.004	0.003	0.12	0.185	0.004	0.004	0.096	0.275
R	0.217				0.319			
R square	0.047				0.102			
Adjusted R sq.	0.021				0.077			
F	1.826			0.127	4.106			0.004*

*N=153. *p < .05. **p < .01. ***p < .001.* *N=150*

Table 4.39. Phrase A. Multiple regression model 3 (session 1) and model 4 (session 2) for TD children.

	Session 1 - phrase A				Session 2 - phrase A			
Variable	***B***	***SE***	***β***	***p* value**	***B***	***SE***	***β***	***p* value**
Constant	85.052	5.92		0.000	83.52	6.468		0.000
Age	0.737	0.567	0.129	0.196	1.399	0.623	0.22	0.026*
Gender	1.212	2.85	0.034	0.671	1.27	3.088	0.033	0.681
Months training	0.008	0.045	0.016	0.864	0.048	0.05	0.087	0.333
Mins listening	0.004	0.003	0.123	0.172	0.003	0.004	0.065	0.462
R	0.219				0.304			
R square	0.048				0.092			
Adjusted R sq.	0.022				0.067			
F	1.871			0.119	3.69			0.007*

*N=153. *p < .05. **p < .01. ***p < .001.* *N=150*

Table 4.40. Phrase B. Multiple regression model 5 (session 1) and model 6 (session 2) for TD children.

	Session 1 - phrase B				Session 2 - phrase B			
Variable	***B***	***SE***	***β***	***p* value**	***B***	***SE***	***β***	***p* value**
Constant	74.471	6.234		0.000	71.596	7.204		0.000
Age	0.67	0.597	0.112	0.264	1.366	0.694	0.194	0.051
Gender	3.976	3.001	0.108	0.187	4.568	3.439	0.106	0.186
Months training	-0.017	0.048	-0.032	0.726	0.022	0.055	0.036	0.692
Mins listening	0.003	0.003	0.091	0.318	0.006	0.004	0.123	0.165
R	0.188				0.298			
R square	0.035				0.089			
Adjusted R sq.	0.009				0.064			
F	1.36			0.251	3.532			0.009*

*N=153. *p < .05. **p < .01. ***p < .001.* *N=150*

4.6 Chapter discussion and summary

The current chapter presents the results of experiment 2, which concerns typically developing children categorised into three age groups; 6-8, 9-12, and 13-17. This study is the first to investigate the pitch-by-pitch melodic expectations of children in the context of stimulus repetition, where the core research objective is to investigate the normative age trends concerning the development of schematic, within-group, and veridical expectations. Quantitative and descriptive analyses were conducted at the session, trial, and pitch levels, and were informed by zygonic theory (Ockelford 2006, 2012) and Gestalt-based laws of melody perception (Huron, 2006) with a focus on particular melodic features as set out in the methods chapter. In relation to the hypotheses set out in section 1.5.2 of the literature review, the main findings are outlined below.

Veridical expectations occur at two stages: at the phrase level occurring within a single presentation of the melody, and at the whole melody level occurring in response to trial repetition. Schematic expectations also occur at two stages: sensory features occurring at the local level such as the melodic principle of adjacency and the melody's register, and more complex global melodic features such as phrase boundaries and tonality. Aside from schematic, within-group and veridical expectations, responses have also been found to be influenced by the contour of the melody as a result of the rating task.

In terms of age-related development, schematic and within-group expectations emerge prior to veridical expectations. Results indicate that children as young as 6-8 exhibit expectations that offer a general sense of upcoming musical events. This is signified by moderately consistent expectancy ratings for phrase A, indicating the activation of long-term memory that enables participants to hear the phrase similarly each time it is repeated. It is proposed that 6-8-year-olds' consistent ratings are influenced by an adjacency heuristic whereby intervals of two semitones are more expected than intervals of three semitones, rather than by within-group expectations for pattern continuation. This proposition is supported by the finding that the more complex patterning of phrase B generates few consistent responses from 6-8-year-olds, possibly because the necessary cognitive abilities to form connections between more complex sequences of notes within the context of an unfolding melody (rather than isolated groups of notes) are underdeveloped in young children. The distinction between schematic and within-group expectations is also unclear at ages 9-12 and 13-17 even though descriptive analyses suggest that the pattern of ratings becomes more regular as children enter middle childhood and then adolescence. However, descriptive analysis should be interpreted alongside quantitative analysis. Any significant differences in consistency of ratings between age groups will be addressed in multiple group quantitative comparisons in chapter 6. The emergence of veridical expectations occurring between trials at age 9-12 indicates a developmental change in melodic perception that occurs in middle childhood and continues throughout adolescence. This is supported by a significant influence of stimulus repetition early on in each experimental session, which also accords with the finding that the dispersion of ratings reduces systematically during session 1 followed by little change during session 2.

Age-related development of melodic expectations is also influenced by melodic features of increasing complexity whereby participants' attention moves from basic sensory and local melodic features between ages 6-12 to include more complex and global features by age 13-17. From age 6-8, ratings for phrase A accord with an established pattern which appears to become more consistent as children grow older, with the most noticeable increase in consistency between ages 6-8 and 9-12 (the statistical significance of which is examined in chapter 6). The key point is that phrase B does not generate consistent ratings for 6-8-year-olds, implying that it comprises complex melodic features not yet cognised by young children, compared with phrase A. Participants also recognise identical repetition of a pattern before they recognise transposed repetition. For example, 9-12 and 13-17-year-olds' ratings indicate that their expectations for phrase B1 are different from their expectations for phrase B2 whereas phrases B1 and B2 are perceived more similarly to each other by adults. The distinctively low range in phrase B2 is a likely cause of the difference in perception, which dominates expectations in listeners between middle childhood and adolescence. At age 13-17, melodic expectations are influenced by a dynamic combination of basic and complex features which operate in the same way each time the stimulus is repeated. Furthermore, contrary to the hypothesis, the lowest pitch in the stimulus is consistently perceived as unexpected, which indicates that children and adolescents are influenced by the sensory attributes of the pitch.

Overall, these results tie in with existing studies (Voyajolu & Ockelford, 2016; Schellenberg et al., 2002), where melodic expectations undergo gradually more complex developmental changes as age increases. The new contribution to research presented in this chapter is that there are distinct stages at which schematic (general) versus veridical (specific) expectations influence melody perception in response to a repeated melody, and these stages occur within specific age bands.

5 Results: children with high-functioning ASC

This chapter presents results from the third and final experiment, which explores the melodic expectations of high functioning autistic children in a Western musical context. The experimental procedure was identical to the previous two participant groups. The research objective for experiment 3 is to explore how the ‘atypical’ development of children with high-functioning autism influence the interaction between schematic, veridical and within-group expectations in a repeated melodic context?

5.1 Participants

Three children with autism failed to complete the picture card task described in the methods chapter section 2.7 and therefore did not take part in the experiment. Therefore, thirty-two children with high-functioning autism (nine female, 23 male), ranging in age from seven to 16 years (mean age 11.8 years) took part in the experiment. Of the 58% of children who had received private instrumental tuition, 37% played the piano, 42% played guitar or ukulele, and the remaining 21% played drums, steel pans, double bass, trumpet, saxophone or violin. Of the 20 children who reported listening to music, 11 reported listening for 10 hours or less per week, four reported listening for between 10 and 20 hours per week, and five participants reported listening for more than 20 hours per week. 88% of this participant group were British, and the remainder were British-American, British-Bengali, British-Irish or British-Jordanian. One participant attended their second session five days after the first session, and one participant attended their second session fourteen days after the first session.

5.3 Session and trial level analysis (quantitative)

To observe how expectancy ratings might change over time, a succession of ANOVAs compared responses for the melodic stimulus as a whole (section 5.3.1); phrase A (section 5.3.2), and phrase B (5.3.3). Within each section, analysis is focused on the session and trial levels. As explained previously, the decision to first analyse the whole melody followed by analysis of phrase A and phrase B is due to differences in the way that the phrases are presented. For example, the stimulus as a whole may give rise to particular expectations that pertain to a global musical narrative that unfolds over an extended trajectory, yet the repetition of phrase A within that extended narrative may give rise to a different set of expectations that pertain to both global and local perception. Normality tests are provided in Appendix C.

5.3.1 Whole melody

The quantitative analyses presented here pertain to the melodic stimulus as a whole. It is hypothesised that veridical expectations will be slowest to develop in autistic children, which can be assessed by investigating how autistic children's expectancy ratings change between sessions 1 and 2 and between each of the eight trials. Thereafter, comparisons between autistic children and typically developing participants are investigated in chapter 6. Autistic participants' mean responses for each trial are set out in Figure 5.1, which shows that expectancy ratings are highest in session 2, but that there is no linear pattern of expectedness as a result of trial repetition. A one-way repeated measures ANOVA with session as the within-subjects variable reveals a non-significant difference between participants' expectancy ratings for sessions 1 and 2 $F(1, 30) = 2.368$, $p = .134$, partial $\eta^2 = .073$. Following this, a repeated measures ANOVA with trial as the within-subjects variable confirms that there is no significant effect of trial on expectancy ratings $F(3.906, 109.377) = 1.758$, $p = .144$, partial $\eta^2 = .059$. This result implies that autistic children are not sensitive to stimulus repetition, however this is to be investigated at the pitch level later in this chapter.

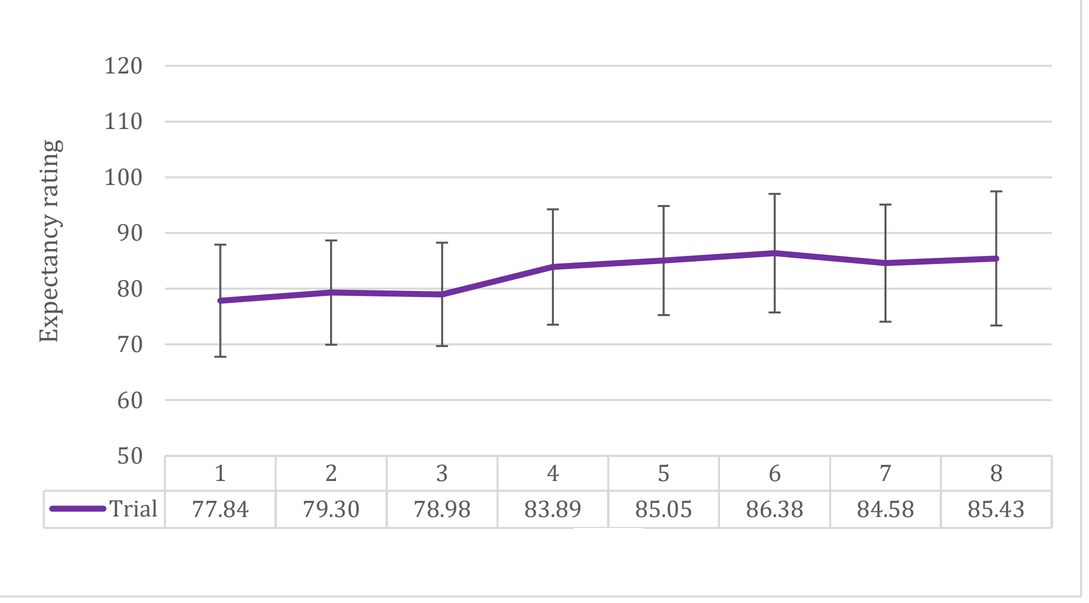


Figure 5.1. Whole melody. **ASC children's mean expectancy ratings for trials 1-8.**

5.3.2 Phrase A

Considering only the notes that comprise phrase A, a one-way repeated measures ANOVA with trial as the within-subjects factor was run to determine whether phrase repetition influences the expectations of autistic participants, and if so, at what point along a continuum this might occur. As the assumption of sphericity was violated, a Greenhouse-Geisser correction was reported, revealing that autistic children were not significantly influenced by trial $F(3.266, 88.185) = .418$, $p = .144$, partial $\eta^2 = .015$, implying that phrase A repetition does not influence expectations (see Figure 5.2 for mean scores). This finding could be due to perceptual dominance at the local level whereby participants attend more closely to isolated pitch values, rather than groups of pitches, resulting in influential schematic expectations that are driven by Gestalt-based principles, but ineffective within-group expectations. This notion can be explored in the pitch-level analysis in section 5.4.

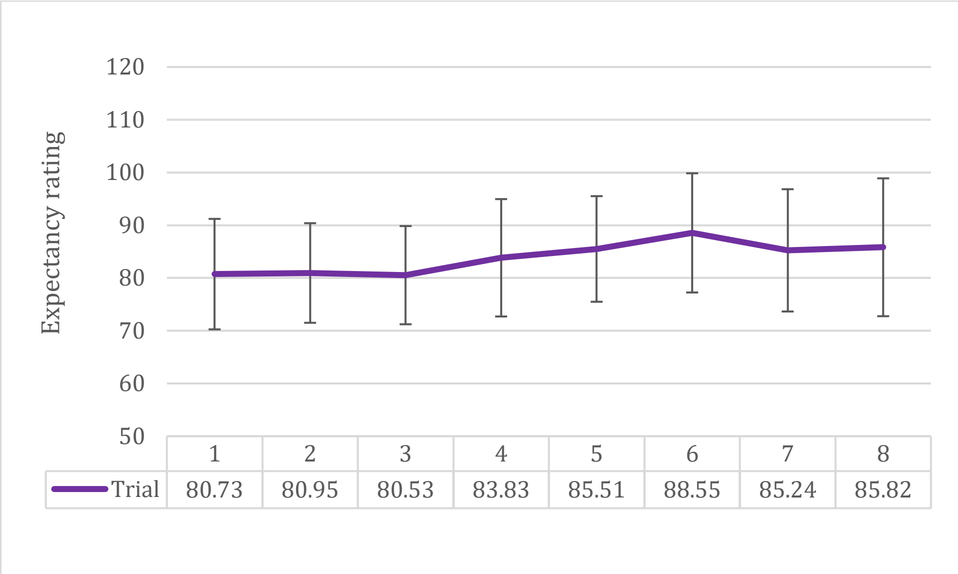


Figure 5.2. Phrase A. ASC children's mean expectancy ratings for trials 1-8.

5.3.2 Phrase B

A one-way repeated measures ANOVA with trial as the within-subjects condition was run to determine whether expectations varied as a function of phrase B repetition. There was no significant effect of trial on expectancy ratings $F(4.478, 116.430) = 1.561$, $p = .183$, partial $\eta^2 = .057$. This result could be due to dominant sensory perception that doesn't take global patterning into account, a result that mirrors the previous paragraph's non-significant result for phrase A.

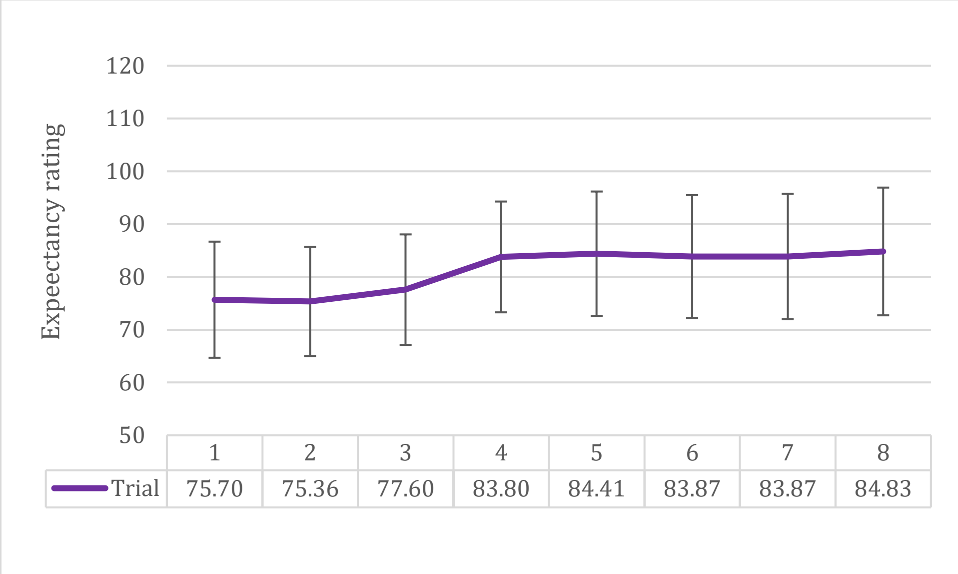


Figure 5.3. Phrase B. ASC children's mean expectancy ratings for trials 1-8.

5.4 Pitch level analysis (descriptive)

Thus far, comparisons between sessions and trials reveal that participants' ratings do not appear to be influenced by trial repetition. This may be due to a preference for attending to sensory melodic features over global features, although given the developmentally challenged nature of children on the autism spectrum (Lord et al., 2000; Rapin & Tuchman, 2008), external influences such as methodological constraints and task comprehension should not be ruled out. Pitch-level analysis may highlight perceptual sensitivities to melodic patterning thereby reducing some ambiguity surrounding confounding variables. Analysis will be driven by the hypothesis that a) schematic expectations – e.g. an intrinsic awareness of melodic structure – are represented as a consistent response pattern that reoccurs in multiple trials; b) that within-group expectations are represented as an expectation for pattern continuation, and c) veridical expectations – e.g. a global awareness of developing musical narrative – will be signified as a progressive increase in expectedness from trial to trial. For reference, the stimulus is re-presented in Figure 5.4.

Figure 5.4. Experimental stimulus.

5.4.1 Phrase A first trial

Figure 5.5 and Table 5.4 present autistic participants' mean expectancy ratings for session 1. Phrase A appears four times in each trial (A1.1, A1.2, A1.3 and A1.4) and comprises two major 2nd intervals followed by one major 3rd interval. Recall that the first pitch is discarded in the analysis, thus the analysable pitch intervals in phrase A1.1 are an ascending major 2nd followed by an ascending major 3rd (see Table 5.4, trial 1, pitches 2-3 and 3-4 in A1.1).

- The expectancy ratings generated in response to A1.1 (a major 2nd followed by a major 3rd) follow a rating pattern that was also identified in chapters 3 and 4 where each major 2nd increases in expectedness and each major 3rd decreases in expectedness.
- The rating pattern continues throughout trial 1, except for the major 3rd in phrase A1.2 which increases in expectedness (see Table 5.4, trial 1, pitches 3-4 in A1.2).

A consistent response pattern implies that autistic participants' ratings for phrase A are influenced by schematic expectations. There is no evidence that repetition alters expectations, thus veridical expectations are not observed at this point.

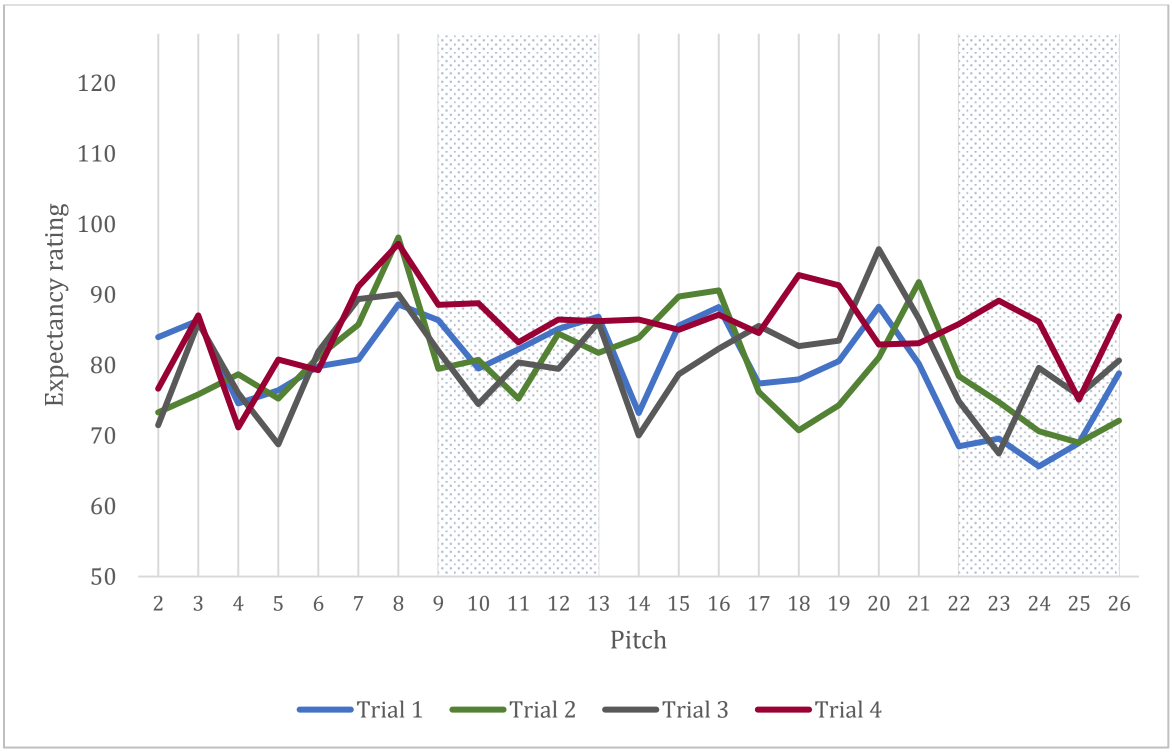


Figure 5.5. ASC children's pitch-level expectancy ratings for trials 1-4 in session 1. Shaded sections signify phrase B.

Table 5.4. Mean pitch-level expectancy ratings for trials 1-4 in session 1. The blue sections relate to phrase B.

Phrase	A1.1			A1.2				B1					A1.3				A1.4				B2				
Pitch	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Trial 1	84	86	75	76	80	81	89	86	80	82	85	87	73	86	88	77	78	81	88	80	68	70	66	69	79
Trial 2	73	76	79	75	81	86	98	79	81	75	84	82	84	90	91	76	71	74	81	92	78	75	71	69	72
Trial 3	72	79	76	69	82	89	90	82	74	80	79	86	70	79	82	86	83	83	96	87	75	67	80	76	81
Trial 4	77	86	71	81	79	91	97	89	89	83	86	86	86	85	87	85	93	91	83	83	86	89	86	75	87

5.4.2 Phrase A repeated trials

Throughout the remaining trials, the rating pattern identified in the first trial is only partly echoed, where most major 2nd intervals are rated as expected in session 1 but appear more random in session 2. Ratings for the major 3rd are inconsistent at the beginning of each trial and are more often rated as unexpected in the second half of each trial. Details are outlined below:

- Ratings for the major 2nd are mostly consistent in session 1 (except for two ratings in trial 4, see Table 5.4, pitches 1-2 in A1.2 and 1-2 in A1.3) but less consistent in session 2.
- In the first half of each trial, the major 3rd is consistently rated as expected for pitches 3-4 in A1.2 (except for trial 5). This contrasts with the expectancy ratings of typically developing children and adults who perceive the major 3rd as surprising early in the experiment.
- In the latter half of each trial, the major 3rd is more often rated as unexpected, but only with moderate consistency (e.g. pitches 3-4 in A1.3 in Tables 5.4 and 5.5).

The results show that overall, ASC children's ratings are different to those of typically developing participants in that there may be a difference in perception between the first and second halves of each trial, and that there is no overall increase in expectedness. This suggests that participants are sensitive to the melody's narrative from start to end but are not considering the repetition in their ratings. Additionally, considering reports that ASC children prefer to focus on local musical properties, the consistent expectedness in response to the major 3rd in the first half of each trial is surprising. One might surmise that participants are imitating the ascending melodic contour rather than perceiving the interval as predictable, which could be attributable to a local processing bias – a postulation that is confirmed in the literature. It is also possible that participants lacked motivation and concentration, or that there are unforeseen methodological or procedural issues. Naturally, analysing participants' ratings with descriptive methods is problematic since it relies on subjective interpretation, however, these methods can explore patterns and nuances that can be co-ordinated with quantitative methods as part of a bigger picture.

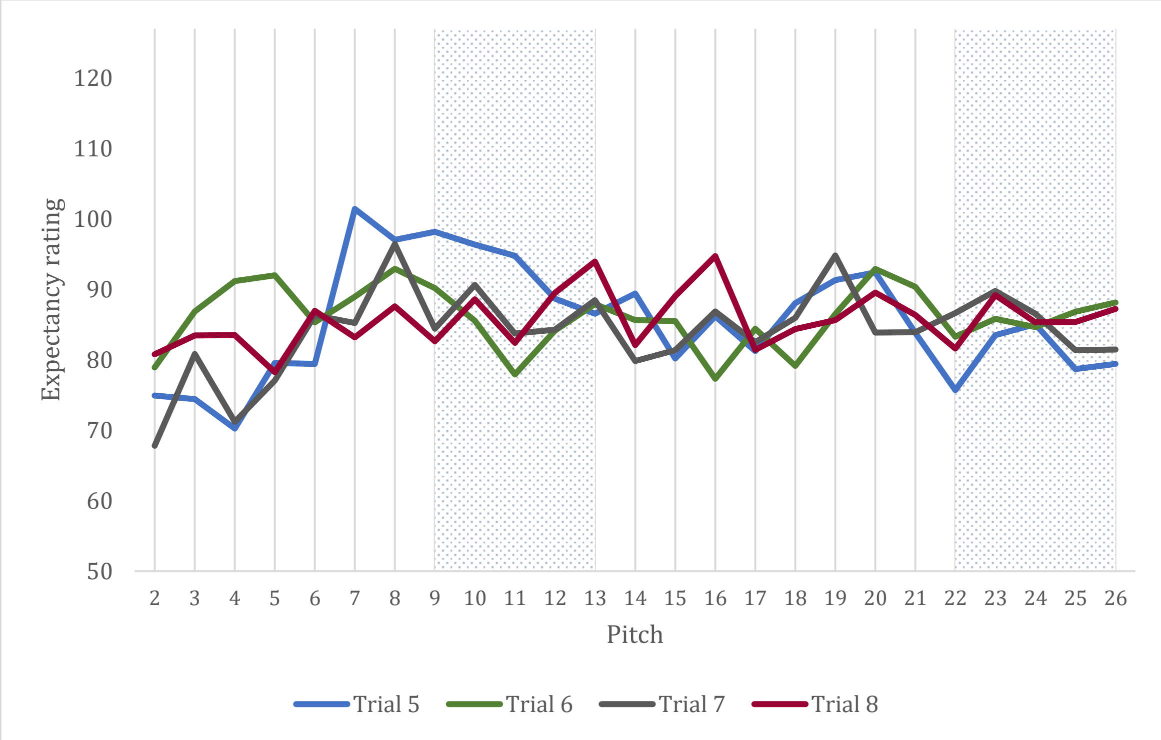


Figure 5.6. ASC children's pitch-level expectancy ratings for trials 5-8 in session 2. Shaded sections signify phrase B.

Table 5.5. ASC children's mean pitch-level expectancy ratings for trials 5-8 in session 2. The blue sections relate to phrase B.

Phrase	A1.1			A1.2				B1					A1.3				A1.4				B2				
Pitch	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Trial 5	75	74	70	80	79	101	97	98	96	95	89	87	89	80	86	81	88	91	92	84	76	84	85	79	79
Trial 6	79	87	91	92	85	89	93	90	86	78	84	88	86	86	77	84	79	87	93	90	83	86	85	87	88
Trial 7	68	81	71	77	86	85	96	84	91	84	84	88	80	81	87	83	86	95	84	84	87	90	87	81	81
Trial 8	81	83	84	78	87	83	88	83	89	82	90	94	82	89	95	81	84	86	90	86	82	89	85	85	87

5.4.3 Phrase B first trial

Phrase B is presented twice in each trial whereby B2 is transposed one fifth lower than B1. The phrase comprises two descending major 2nd intervals followed by an ascending major 3rd and a descending major 2nd.

- Observation of expectancy ratings in trial 1 implies that participants perceive B1 and B2 as distinct from each other. For example, the descending major 2nd from pitches 2-3 in B1 are rated as expected, but the same interval in B2 (pitches 2-3 B2) is rated as unexpected. This result is similar to previously reported findings among TD children and adults that pitch 3 in B2 is consistently rated as surprising due to the low pitch.

- The last three pitches in both B1 and B2 (pitches 3-5) are rated as increasingly expected, which may result from schematic expectations for a phrase ending based on tonal probabilities. This likelihood will be discussed when considering trials 2-8.

5.4.4 Phrase B repeated trials

In contrast to the ratings of TD children and adults, autistic children's ratings for phrases B1 and B2 are less distinct from each other in the remaining trials. Highlights from sessions 1 and 2 are described below.

- During session 1, the pattern continuation from pitches 2-3 in B1 in trials 2 and 4 is regarded as surprising, whereas TD participants rate the pattern continuation as expected. This could be explained here as contour imitation.
- The same interval in B2 (pitches 2-3) is also rated as unexpected in trials 2 and 4. This finding is similar to that of TD adults and children, and therefore indicates some influence of melodic contour or pitch range that may be applicable to all participants (TD and autistic).
- During trials 2-4, participants expect the final interval in phrase B2, demonstrating an expectation for closure. The same expectation is unclear for B1 as this only occurs in trials 1 and 3.
- During session 2, trials 5-8, pitches 2-3 in phrase B1 are consistently rated as surprising. The parallel interval in phrase B2 (pitches 2-3) is also rated as surprising in trials 6-8. This reinforces the postulation that participants may be

more influenced by melodic contour rather than a probabilistic or Gestalt process.

- An expectation for closure based on tonality is observed for phrase B1 in trials 6-8, and phrase B2 in trials 5-8, highlighting a schematic influence.

These results show that there is no observable rating pattern for the phrase as a whole, but there are consistent ratings for specific intervals. For example, the second interval in phrase B continues a descending pattern but is consistently regarded as surprising (in phrases B1 and B2), which suggest that melodic contour is a more dominant influence than within-group expectations in children with ASC. The robust schematic expectation for closure demonstrates that tonal stability at phrase endings is a dominant influence on perception. Even though autistic participants' ratings do not encapsulate the melody as whole, the schematic expectation for closure indicates that participants are retaining some memory for the narrative structure of the melody. Furthermore, there is no evidence of veridical expectations for phrase B, as ratings do not increase linearly, and they are clustered around the same range. It should be noted that despite the results presented here, there are numerous inconsistencies in the responses pertaining to phrase B, therefore the descriptive analysis should be understood alongside the quantitative analysis presented earlier in the chapter.

5.4.5 Rating distribution

The functionality between the different forms of expectation can be more closely investigated by observing how the distribution of expectancy ratings alters for each trial. A rating distribution that decreases as the trials unfold might indicate an increasing dominance of veridical expectations and a dampening of schematic and within-group expectations. Table 5.6 presents the difference in mean ratings between each pitch aggregated by trial, revealing no observable pattern of change across trials or between sessions. Additionally, as expressed in chapters 3 and 4, measuring the correlation between each pair of pitches within a trial can also give some indication as to the regularity of responses. These results displayed in tables 5.7 and 5.8 show that there is a tendency for the autocorrelation coefficient to increase throughout trials 1-8. However, a follow up test using an r to z transformation reveals no significant differences between the correlation coefficients. Additionally, unlike all typically developing participant groups, the intercept does not increase systematically. This implies that the ratings of autistic participants may become more regular with repetition, but do not necessarily increase in expectedness. This supports the earlier finding that the ratings of autistic children do not increase significantly between sessions, and that there are pockets of consistent response patterns among seemingly random ratings.

Table 5.6. ASC children's mean differences between pitches, split by trial.

Session	Trial	Mean
Session 1	Trial 1	5.548
	Trial 2	6.033
	Trial 3	7.500
	Trial 4	5.400
Session 2	Trial 5	5.024
	Trial 6	4.413
	Trial 7	5.738
	Trial 8	5.021

Table 5.7. ASC children's autocorrelation coefficients (*ø*) for sessions 1 and 2.

Session	Intercept	*p value*	ϕ	*p value*	Std D
Session 1	79.839	0.000***	0.397	0.000***	4.911
Session 2	84.274	0.000***	0.476	0.000***	5.838

*$p < .05$. **$p < .01$. ***$p < .001$.

Table 5.8. ASC children's autocorrelation coefficients (ø) for trials 1-8.

Session	Trial	Intercept	*p value*	ϕ	*p value*	Std D
Session 1	Trial 1	77.943	0.000***	0.309	0.000***	5.781
	Trial 2	75.032	0.000***	0.401	0.000***	6.307
	Trial 3	77.916	0.000***	0.405	0.000***	6.203
	Trial 4	84.129	0.000***	0.405	0.000***	6.702
Session 2	Trial 5	83.687	0.000***	0.43	0.000***	6.587
	Trial 6	85.581	0.000***	0.5	0.000***	7.311
	Trial 7	81.623	0.000***	0.52	0.000***	7.303
	Trial 8	84.915	0.000***	0.533	0.000***	7.446

*$p < .05$. **$p < .01$. ***$p < .001$.

5.5 Analysis of questionnaire items

As described in the methods chapter, one's musical history may have some impact on their expectancy ratings in this experiment. Therefore, a series of multiple linear regressions were conducted with a) gender, b) months of instrumental tuition; and c) minutes spent listening to music per week. Gender was categorised as a dummy variable coded 0 for females and 1 for males, and the other two variables were categorised as continuous. A multiple regression was performed for each of the following pitch combinations:

- All 200 pitches in session 1 (model 1)
- All 200 pitches in session 2 (model 2)
- Phrase A 60 pitches in session 1 (model 3)
- Phrase A 60 pitches in session 2 (model 4)
- Phrase B 40 pitches in session 1 (model 5)
- Phrase B 40 pitches in session 2 (model 6)

As depicted in Tables 5.9, 5.10, and 5.11, the results reveal that gender, months of instrumental lessons and time spent listening to music are not significant predictors for participants' performance on the rating task, and are thus not significant indicators of participants' melodic expectation. It could be interpreted that all participants respond in a similar way, however the small number of respondents of varying ages should be taken into account.

Table 5.9. Whole melody. Multiple regression model 1 (session 1) and model 2 (session 2) for ASC children.

	Session 1 - whole melody				**Session 2 - whole melody**			
Variable	***B***	***SE***	***β***	***p* value**	***B***	***SE***	***β***	***p* value**
Constant	82.708	9.887		0.000	87.158	12.106		0.000
Gender	0.255	10.775	0.005	0.981	1.556	12.9	0.024	0.905
Months training	-0.07	0.153	-0.088	0.649	-0.077	0.175	-0.087	0.661
Mins listening	-0.002	0.007	-0.051	0.795	-0.002	0.008	-0.056	0.776
R	0.103				0.107			
R square	0.011				0.011			
Adjusted R sq.	-0.099				-0.103			
F	0.096			0.961	0.959			0.959

*N=31. *p < .05. **p < .01. ***p < .001.* *N=30*

Table 5.10. Phrase A. Multiple regression model 3 (session 1) and model 4 (session 2) for ASC children.

	Session 1 - phrase A				Session 2 - phrase A			
Variable	***B***	***SE***	***β***	***p* value**	***B***	***SE***	***β***	***p* value**
Constant	82.192	10.087		0.000	84.719	12.651		0.000
Gender	1.373	10.993	0.024	0.902	3.262	13.48	0.047	0.811
Months training	-0.05	0.156	-0.062	0.751	0.102	0.183	0.108	0.581
Mins listening	0.000	0.007	-0.002	0.99	-0.004	0.008	-0.099	0.615
R	0.066				0.149			
R square	0.004				0.022			
Adjusted R sq.	-0.106				-0.091			
F	0.04			0.989	0.197			0.898
*N=31. *p < .05. **p < .01. ***p < .001.*					*N=30*			

Table 5.11. Phrase B. Multiple regression model 5 (session 1) and model 6 (session 2) for ASC children.

	Session 1 - phrase B				Session 2 - phrase B			
Variable	***B***	***SE***	***β***	***p* value**	***B***	***SE***	***β***	***p* value**
Constant	83.37	10.318		0.000	90.43	12.48		0.000
Gender	-1.13	11.245	-0.019	0.921	-0.621	13.298	-0.009	0.963
Months training	-0.103	0.159	-0.123	0.522	-0.331	0.18	-0.34	0.077
Mins listening	-0.004	0.007	-0.107	0.581	0.001	0.008	0.017	0.927
R	0.168				0.34			
R square	0.028				0.115			
Adjusted R sq.	-0.8				0.013			
F	0.26			0.853	0.355			0.355
*N=31. *p < .05. **p < .01. ***p < .001.*					*N=30*			

5.6. Chapter discussion and summary

The objective of experiment 3 was to understand how autistic children perceive melodic repetition compared with typically developing children in reference to Ockelford's zygonic theory. The key findings in relation to the hypotheses are outlined below, which offer novel insight into the melodic expectancies of autistic children in response to repetition of a stimulus. As hypothesised, the main source from which expectations arise are deep-rooted low-level cognitive processes which can be categorised as schematic expectations. Many of the ratings provided by autistic participants appear random, and only partly adhere to the response patterns that have been identified by typically developing participants pertaining to major 2^{nd} and major 3^{rd} intervals. There are, however, two consistent indicators of schematic expectations that were revealed from the descriptive analysis. The first is that autistic participants tend to expect pitches to be proximate, as discussed in the descriptive analysis of phrase A. However there does not appear to be any pattern awareness that extends beyond two pitches. This suggests that due to a local processing bias, ASC participants rely on absolute perception and local melodic features, which also supports the hypothesis that within-group expectations are superseded by schematic expectations. The second indicator of schematic expectations pertains to tonality in relation to temporal structure. Descriptive analysis of ratings for phrase B show a robust expectation for tonal stability at phrase endings. This occurs despite the finding that participants are also influenced by melodic contour. As knowledge of tonality and grouping boundaries both function at the global level before they can be recognised at the local level, it is argued that some aspect of global processing is in operation, highlighting the salience of grouping boundaries in melody perception and cognition. Aside from schematic expectations, the melodic contour was identified as a strong influence on melodic expectations. For example, instances of seeming 'expectedness' occurred in response to melodic features that are most likely to be surprising, such as non-proximate changes in pitch direction. Therefore, in tandem with reports that ASC children exhibit a local processing bias, it is reasoned that participants were following the contour rather than expressing perceived expectedness.

There was no perceptible influence of whole melody or phrase repetition on expectancy ratings, which supports the hypothesis that veridical expectations are slow to develop in children with autism. No significant differences were found between sessions, and this was corroborated in the pitch-level descriptive analyses, where there was no evidence of a cumulative impact of phrase or trial repetition. Additionally, the distribution of expectancy ratings did not alter as a function of repetition which also supports the notion that veridical expectations are subordinate in children with high-functioning autism. Unlike TD children aged 9+, the autocorrelation intercept did not change, which suggests that the overall expectedness did not increase. Additionally, there were no significant differences between the autocorrelation coefficients, which indicates that the regularity of responses was similar throughout all trials.

Overall these results show that the melodic expectations of children with ASC are different to the expectations exhibited by typically developing children in that autistic children exhibit a preference for local processing. This accords with the finding that within-group and veridical expectations are slower to develop in autistic children. Notably, these results indicate that the schematic expectations of autistic children are guided by distinctive features that are intrinsically related to a ‘local’ processing bias. For example, TD children aged 9+ are influenced by grouping principles relating to melodic patterns that extend beyond two intervals, whereas autistic children (ranging in age from 8-17 in the present study) are guided by pitch adjacency and closure. As a result, within-group expectations for long sequences of notes seem less influential in autistic listeners than in their TD peers. On the surface, one might deduce that the veridical expectations of autistic children are on par developmentally with TD children aged 6-8. However, since autistic children may be influenced by melodic contour in this experiment, the similarities are less obvious. More directed discussion will emerge in the following chapter as a result of statistical comparisons across all three participant groups.

6 Between-group comparisons

The findings presented thus far demonstrate developmental differences in the way that repeated melodic stimuli are perceived with respect to schematic, veridical, and within-group expectations (Ockelford, 2012). The current chapter addresses research question 4: Is there a difference in the developing interaction between different forms of expectation between each participant group? As the quantitative analyses focus on mean ratings at the melody and phrase levels, and do not consider ratings at the pitch level, the current chapter highlights developmental changes pertaining to veridical expectations. To recap, the participant groups are typically developing (TD) children aged 6-8 (*Mean* = 7.83, *Standard Deviation* = .78), TD children aged 9-12 (*M* = 10.61, *SD* = 1.13), TD children aged 13-17 (*M* = 14.82, *SD* = .92), TD adults (*M* = 33.23, *SD* = 12.57), and high-functioning autistic children (*M* = 11.8, *SD* = 2.73). The number of participants split by gender is displayed in Table 6.1. All participant groups underwent the same experimental procedure.Repeated measures ANOVAs explored interactions between session x participant group, and between trial x participant group, and will be discussed in section 6.2. Thereafter, in section 6.3 the coherence of response patterns within and between each trial is investigated using time series analysis, which measures the correlation between each pair of pitches. The significance of the differences between autocorrelation coefficients were conducted between participant groups for each trial. Section 6.4 summarises the chapter.

6.2 Session and trial level analysis

A two-way repeated measures ANOVA with participant group as the independent variable was performed for a) the stimulus as a whole; b) phrase A, and c) phrase B. It was established in chapters 3-5 that the distribution of data was moderately normal and therefore suitable for analysis. Table 6.1 displays the participant numbers according to group and gender.

6.2.1 Whole melody

Figure 6.1 shows each participant group's mean ratings for sessions 1 and 2. Visual observation indicates that mean ratings increase as a function of age, and that all participant groups rated the second session as more predictable than the first. Table 6.2 shows that autistic children exhibited the most variance in ratings, whereas all other groups were more similar to each other. A two-way 2 x 5 repeated measures ANOVA with session as the within-subjects factor and participant group as the between-subjects factor was conducted, demonstrating a significant main effect of group $F(1, 4) = 9.706$, $p = .000$, partial $\eta^2 = .156$, a significant difference in expectancy ratings between session 1 and session 2 $F(1, 210) = 38.211$, $p = .000$, partial $\eta^2 = .154$, but no significant interaction between session and participant group $F(4, 210) = 1.480$, $p = .209$, partial $\eta^2 = .027$.

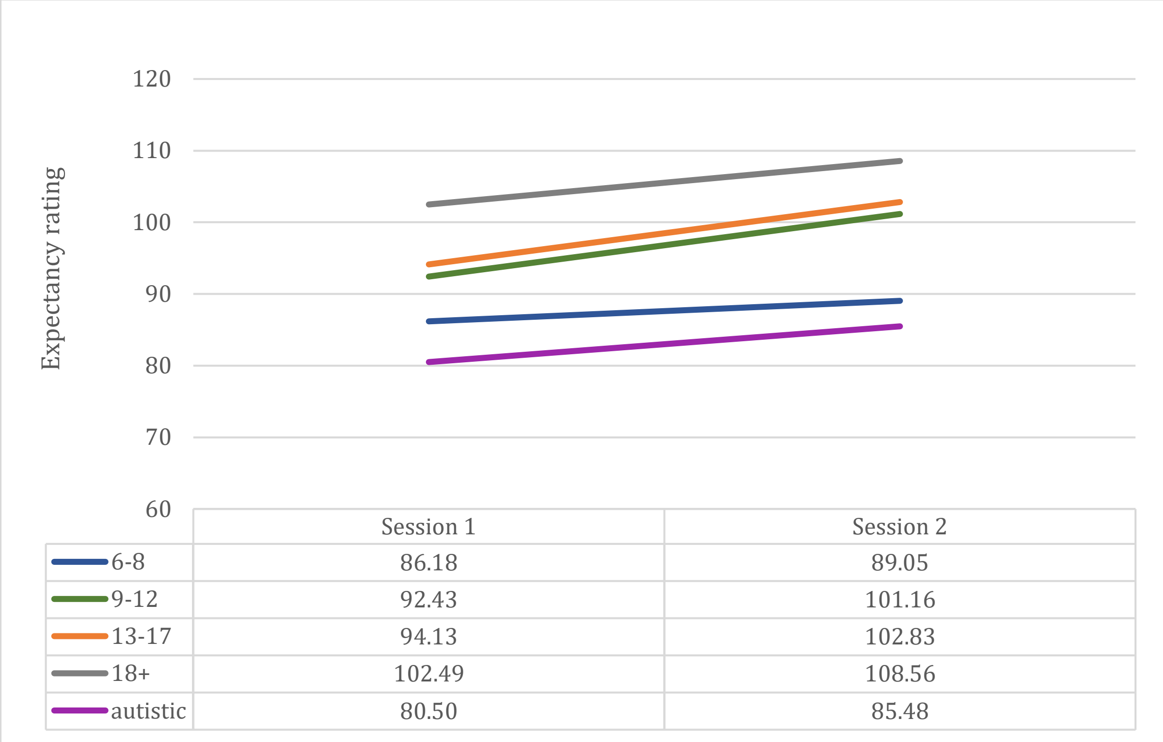
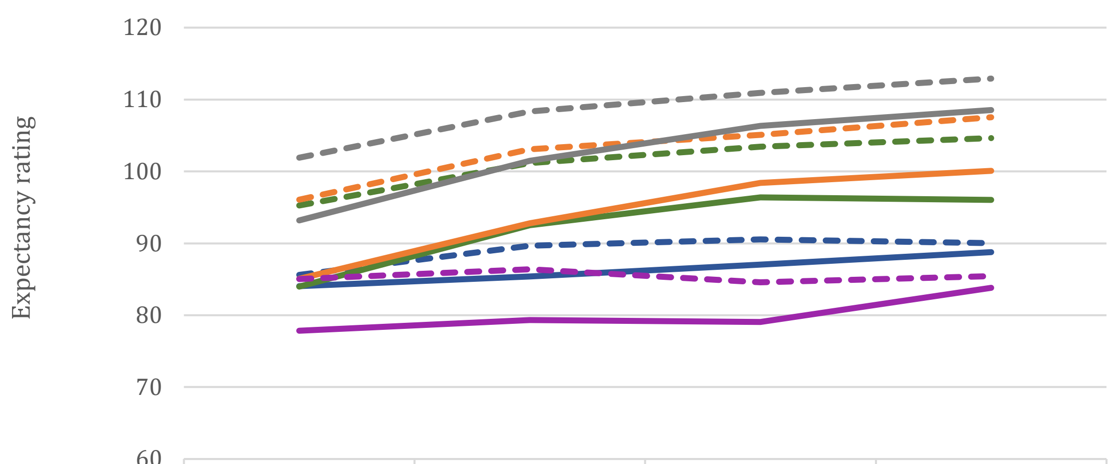


Figure 6.1. Mean expectancy ratings for sessions 1 and 2 comparing all participant groups.

Table 6.2. Descriptive statistics for sessions 1 and 2 comparing all participant groups.

Participant group	Session 1			Session 2		
	Mean	***SD***	**N**	**Mean**	***SD***	**N**
6-8	86.18	16.18	44	89.05	19.48	44
9-12	92.43	17.13	50	101.16	18.61	50
13-17	94.13	16.04	62	102.83	16.41	58
18+	102.49	14.02	43	108.56	15.21	34
Autistic	80.50	24.44	32	85.48	27.91	31



	Trial 1/5	Trial 2/6	Trial 3/7	Trial 4/8
6-8	84.05	85.41	87.02	88.77
6-8	85.61	89.68	90.55	90.02
9-12	83.98	92.51	96.39	96.06
9-12	95.27	101.16	103.43	104.63
13-17	85.06	92.79	98.39	100.08
13-17	96.07	103.07	105.07	107.53
18+	93.19	101.49	106.33	108.53
18+	101.91	108.35	110.91	112.91
autistic	77.84	79.34	79.06	83.81
autistic	85.03	86.39	84.58	85.45

Figure 6.2. Mean expectancy ratings for trials 1-8 comparing all participant groups. Plain lines represent trials 1-4 in session 1, and dashed lines represent trials 5-8 in session 2.

Figure 6.2 displays participants' mean ratings for trials 1-8. It is evident that mean expectedness increases with age for each trial, and this is confirmed by a repeated measures ANOVA with trial as the within-subjects factor and participant group as the between-subjects factor. The results reveal a significant effect for trial x participant group with a small effect size $F(14.496, 753.797) = 2.331$, $p = .003$, partial $\eta^2 = .043$. A Games-Howell post-hoc test for the main effect of age demonstrates that the responses of children aged 6-8 are significantly lower than children aged 13-17 ($p = .005$) and adults ($p = .000$), and that the ratings of autistic children are significantly lower than TD children aged 13-17 ($p = .036$), and TD adults ($p = .001$). A Games-Howell test was selected as a result of a significant Levene's test, revealing that the homogeneity of variance assumption required for conducting an ANOVA was violated.

A follow up univariate ANOVA with participant group as the between-subjects factor was performed separately for each trial to look at the interaction, the results of which are presented in Table 6.3. Each univariate ANOVA is significant, which demonstrates that between-group variation occurs in all trials.

Table 6.3. Whole melody - Univariate ANOVA for trial x participant group.

Trial	**F**	***p* value**	**Partial eta squared**
Trial 1	3.045	0.018*	0.051
Trial 2	7.242	0.000***	0.114
Trial 3	12	0.000***	0.176
Trial 4	8.304	0.000***	0.129
Trial 5	5.025	0.001**	0.087
Trial 6	7.525	0.000***	0.125
Trial 7	10.049	0.000***	0.16
Trial 8	11.038	0.000***	0.174

*p < .05. **p < .01. ***p < .001. N=230

Games-Howell post-hoc tests (see Table 6.4) indicate the groups that differ during each trial. 6-8-year-olds' ratings are significantly lower than adults' in trials 2-8, and significantly lower than 13-17-year-olds in trials 3, 4, 6, 7, and 8. Furthermore 6-8-year-olds' ratings are significantly lower than 9-12-year-olds' ratings in trials 7 and 8. There are no significant differences between age groups 9-12 and 13-17, and between age groups 13-17 and 18+. This shows that the difference between typically developing age groups widens as the number of trial repetitions increases. Ratings provided by autistic children are significantly lower than adults' ratings in trials 2-8 and significantly lower than 13-17-year-olds' ratings in trials 3, 4, 6, 7, and 8. Autistic children also present significantly lower ratings than 9-12-year-olds during trials 3, 7, and 8. As hypothesised, there are no significant differences between autistic children and TD 6-8-year-olds. Tables D1, D2, and D3 in Appendix D show more detailed results from the post-hoc tests for a) the repeated measures ANOVA with trial as the within-subjects factor and participant group as the between-subjects factor, and b) the univariate ANOVAs that were conducted for each trial. These tables include the mean difference, standard error and 95% confidence intervals.

Table 6.4. Whole melody. Games-Howell post-hoc tests comparing differences between all participant groups for each trial.

Participant group		**Session 1 *p* values**				**Session 2 *p* values**			
		Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8
6-8	9-12	1.000	0.418	0.111	0.400	0.151	0.061	0.025*	0.014*
	13-17	0.998	0.293	0.014*	0.029*	0.064	0.007**	0.003**	0.001**
	18+	0.097	0.001**	0.000***	0.000***	0.002**	0.000***	0.000***	0.000***
	ASC	0.806	0.804	0.560	0.922	1.000	0.982	0.858	0.964
9-12	6-8	1.000	0.418	0.111	0.400	0.151	0.061	0.025*	0.014*
	13-17	0.997	1.000	0.980	0.817	0.999	0.988	0.992	0.929
	18+	0.082	0.100	0.055	0.033*	0.413	0.428	0.385	0.217
	ASC	0.811	0.112	0.015*	0.241	0.359	0.110	0.02*	0.042*
13-17	6-8	0.998	0.293	0.014*	0.029*	0.064	0.007**	0.003**	0.001**
	9-12	0.997	1.000	0.980	0.817	0.999	0.988	0.992	0.929
	18+	0.135	0.060	0.118	0.199	0.455	0.603	0.553	0.556
	ASC	0.681	0.078	0.003**	0.043	0.250	0.041	0.007**	0.010*
18+	6-8	0.097	0.001**	0.000***	0.000***	0.002**	0.000***	0.000***	0.000***
	9-12	0.082	0.100	0.055	0.033*	0.413	0.428	0.358	0.217
	13-17	0.135	0.060	0.118	0.199	0.455	0.603	0.553	0.556
	ASC	0.058	0.001**	0.000***	0.001**	0.028*	0.005**	0.001**	0.001**
ASC	6-8	0.806	0.804	0.560	0.922	1.000	0.982	0.858	0.964
	9-12	0.811	0.112	0.015*	0.241	0.359	0.110	0.02*	0.042*
	13-17	0.681	0.078	0.003**	0.043*	0.250	0.041*	0.007**	0.010*
	18+	0.058	0.001**	0.000***	0.001**	0.028*	0.005**	0.001**	0.001**

*$p < .05$. **$p < .01$. ***$p < .001$. Session 1 $N = 230$. Session 2 $N = 216$

With respect to this chapter's objective which is to highlight between-group differences pertaining to veridical expectations, the above results indicate important age differences in melodic perception that are magnified by stimulus repetition, as shown in two examples. First, the results demonstrate that young children exhibit significantly weaker veridical expectations compared with adults, and this is not modified by stimulus repetition, since 6-8-year-olds' ratings are significantly lower than adults' throughout trials 2-8. Second, the perceptual difference between 6-8-year-olds and 13-17-year-olds is largest when repetition has occurred cumulatively within a session during which memory for repetition has chance to accumulate, rather than at the beginning of a session that follows a period of memory decay (see the significant difference between 6-8 and 13-17-year-olds in trials 3-4 and 6-8, but no significant difference in trial 5). The same two examples exist between autistic children and adults, and between autistic children and 13-17-year-olds. This implies that the veridical expectations of autistic children and 6-8-year-olds may function similarly. However, since the literature indicates that autistic children tend to focus on local musical properties (e.g. Mottron et al., 2006), the mechanisms that underpin the operation of veridical expectations may differ.

6.2.2 Phrase A

A repeated measures ANOVA concerning only the pitches that comprise phrase A was conducted, whereby trial was the within-subjects factor and participant group was the between-subjects factor. Results show a significant interaction between trial and participant group on expectancy ratings, with a small effect size $F(14.837, 767.831) = 1.845$, $p = .026$, partial $\eta^2 = .034$. The main effect of age was examined using a Games-Howell post-hoc test, which revealed significantly lower ratings for 6-8-year-olds compared to children aged 9-12 ($p = .047$), 13-17 ($p = .006$), and adults ($p = .000$). The ratings of children aged 9-12 are also significantly lower than adults (p = .040). Furthermore, autistic children's ratings are significantly lower than children aged 9-12 ($p = .021$), 13-17 ($p = .008$) and adults ($p = .000$).

Next, a univariate ANOVA was conducted separately for each trial to assess the interaction between participant group and trial, all of which show a significant overall effect of participant group (see Table 6.5). A Games-Howell post-hoc test (Table 6.6) was conducted for each trial, and results reveal that the ratings of TD children aged 6-8 are significantly lower than those of adults in trials 1-8. Children aged 6-8 also rate significantly lower than 13-17-year-olds in trials 3-8, and significantly lower than 9-12-year-olds in trials 3 and 8. 9-12-year-olds' ratings are significantly lower than adults' ratings in trials 1-4. Children aged 13-17 provide significantly lower ratings than adults in trials 1-3. Autistic children's ratings are also significantly lower than 9-12-year-olds in trials 3, 7, and 8. Furthermore, autistic children give significantly lower ratings than 13-17-year-olds in trials 2-8, and are significantly lower than adults in all trials. There are no significant differences between autistic children and TD children aged 6-8. These findings are supported by the additional results in Appendix D (Tables D4, D5, and D6) which show post-hoc tests for a) the repeated measures ANOVA with trial as the within-subjects factor and participant group as the between-subjects factor, and b) the univariate ANOVAs that were conducted for each trial.

Table 6.5. Phrase A. Univariate ANOVA for trial x participant group.

Trial	F	*p* value	Partial eta squared
Trial 1	5.114	0.001**	0.083
Trial 2	10.824	0.000***	0.161
Trial 3	15.653	0.000***	0.218
Trial 4	10.999	0.000***	0.164
Trial 5	7.856	0.000***	0.13
Trial 6	8.584	0.000***	0.14
Trial 7	11.331	0.000***	0.178
Trial 8	11.168	0.000***	0.176

*p < .05. **p < .01. ***p < .001. N=230

Table 6.6. Phrase A. Games-Howell post-hoc tests comparing differences between all participant groups for each trial.

Participant group		Session 1 *p* values				Session 2 *p* values			
		Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8
6-8	9-12	0.977	0.488	0.04*	0.518	0.091	0.054	0.051	0.033*
	13-17	0.993	0.138	0.005**	0.049*	0.020*	0.011*	0.011*	0.004**
	18+	0.004**	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
	ASC	0.829	0.671	0.446	0.500	0.963	0.933	0.560	0.762
9-12	6-8	0.977	0.488	0.04*	0.518	0.091	0.054	0.051	0.033*
	13-17	1.000	0.952	0.989	0.780	0.996	0.999	0.997	0.979
	18+	0.018*	0.003**	0.037*	0.011*	0.247	0.290	0.307	0.204
	ASC	0.585	0.066	0.002**	0.057	0.083	0.060	0.007**	0.021*
13-17	6-8	0.993	0.138	0.005**	0.049*	0.020*	0.011	0.011*	0.004**
	9-12	1.000	0.952	0.989	0.780	0.996	0.999	0.997	0.979
	18+	0.005**	0.011*	0.055*	0.095	0.308	0.275	0.381	0.385
	ASC	0.643	0.015*	0.000***	0.006**	0.035	0.029*	0.003**	0.008**
18+	6-8	0.004**	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
	9-12	0.018*	0.003**	0.037*	0.011*	0.247	0.290	0.307	0.204
	13-17	0.005**	0.011*	0.055	0.095	0.308	0.275	0.381	0.385
	ASC	0.007**	0.000***	0.000***	0.000***	0.001**	0.001**	0.000***	0.000***
ASC	6-8	0.829	0.671	0.446	0.500	0.963	0.933	0.560	0.762
	9-12	0.585	0.066	0.002**	0.057	0.083	0.060	0.007**	0.021*
	13-17	0.643	0.015*	0.000***	0.006**	0.035*	0.027*	0.003**	0.008**
	18+	0.007**	0.000***	0.000***	0.000***	0.000***	0.001**	0.000***	0.001**

*p < .05. **p < .01. ***p < .001. Session 1 N = 230. Session 2 N = 216

The above results indicate that veridical expectations for phrase A operate similarly to expectations for the whole melody, in that the difference between groups increases as the age gap widens. This is also enhanced by trial repetition, in that a greater number of between group differences occurs as the number of trial repetitions increases. Unlike the whole melody results, the significant differences between groups continue throughout all trials, even despite the 7-day gap between sessions, implying heightened veridical influence for phrase A.

6.2.3 Phrase B

A repeated measures ANOVA was conducted considering only the pitches that comprise phrase B, with trial as the within-subjects factor, and participant group as the between-subjects factor. Results reveal a significant interaction between trial and participant group on expectancy ratings, with a small effect size $F(16.410, 841.017) = 2.451$, $p = .001$, partial $\eta^2 = .046$. A further Games-Howell post-hoc test reveals that 6-8-year-olds' ratings are significantly lower than 13-17-year-olds ($p = .035$) and adults ($p = .004$). There are no other significant differences between participant groups.

A univariate ANOVA was performed for each trial (see Table 6.8), and a main effect of participant group was confirmed for all trials excluding 1 and 5. Post-hoc analyses show that TD 6-8-year-olds' ratings are significantly lower than adults' ratings in trials 3, 4, 7, and 8, and 13-17-year-olds in trials 7 and 8. Children aged 6-8 also exhibit significantly lower ratings than 9-12-year-olds in trial 8. Finally, the ratings of autistic children are significantly lower than adults' in trials 2, 3, 7, and 8.

Table 6.7. Phrase B. Univariate ANOVA for trial x participant group.

Trial	F	*p* value	Partial eta squared
Trial 1	0.53	0.714	0.009
Trial 2	2.624	0.036*	0.045
Trial 3	4.31	0.002**	0.071
Trial 4	3.543	0.008**	0.059
Trial 5	1.387	0.24	0.026
Trial 6	4.407	0.002**	0.077
Trial 7	4.901	0.001**	0.085
Trial 8	8.273	0.000***	0.137

*$p < .05$. **$p < .01$. ***$p < .001$. N=230

Table 6.8. Phrase B. Games-Howell (trials 1, 5, 6, and 8) and Tukey HSD (trials 2, 3, 4, and 7) post-hoc tests comparing differences between participant groups for each trial.

Participant group		Session 1 *p* values				Session 2 *p* values			
		Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8
6-8	9-12	n/a	0.467	0.682	0.636	n/a	0.182	0.124	0.023*
	13-17	n/a	0.870	0.339	0.187	n/a	0.023	0.028*	0.001**
	18+	n/a	0.275	0.025*	0.007**	n/a	0.021	0.007**	0.000***
	ASC	n/a	0.868	0.984	0.994	n/a	1.000	1.000	0.999
9-12	6-8	n/a	0.467	0.682	0.636	n/a	0.182	0.124	0.025*
	13-17	n/a	0.932	0.987	0.944	n/a	0.978	0.987	0.878
	18+	n/a	0.994	0.385	0.223	n/a	0.810	0.699	0.435
	ASC	n/a	0.098	0.206	0.905	n/a	0.390	0.197	0.225
13-17	6-8	n/a	0.870	0.339	0.187	n/a	0.023	0.028*	0.001**
	9-12	n/a	0.932	0.987	0.944	n/a	0.978	0.987	0.878
	18+	n/a	0.757	0.629	0.572	n/a	0.955	0.904	0.864
	ASC	n/a	0.319	0.061	0.513	n/a	0.167	0.062	0.048
18+	6-8	n/a	0.275	0.025*	0.007**	n/a	0.021	0.007**	0.000***
	9-12	n/a	0.994	0.385	0.223	n/a	0.810	0.699	0.435
	13-17	n/a	0.757	0.629	0.572	n/a	0.955	0.904	0.864
	ASC	n/a	0.046*	0.003**	0.052	n/a	0.100	0.015*	0.014*
ASC	6-8	n/a	0.868	0.894	0.995	n/a	1.000	1.000	0.999
	9-12	n/a	0.098	0.206	0.905	n/a	0.390	0.197	0.225
	13-17	n/a	0.319	0.061	0.513	n/a	0.167	0.062	0.048*
	18+	n/a	0.046*	0.003**	0.052	n/a	0.100	0.015*	0.014*

*$p < .05$. **$p < .01$. ***$p < .001$. Session 1 $N = 230$. Session 2 $N = 216$

Between-group expectations for phrase B are less systematic than for phrase A, as evidenced by the non-significant main effect of participant group in trials 1 and 5 (Table 6.7). This demonstrates that variance between groups start to occur after the second trial, that the break between sessions minimises the between-group differences, after which the sixth trial causes between-group variance to reoccur. This finding infers that veridical expectations are less cumulative for phrase B compared with phrase A. This is also supported by the univariate ANOVA results in Table 6.8 which show that significant differences in expectations between 6-8-year-olds and adults do not continue from trial 1 through 8, unlike the ratings given for phrase A. The same finding is apparent between autistic children and adults.

6.3 Rating distribution – between-group comparisons

This section investigates the time series analysis results that were presented in chapters 3, 4, and 5. Tables 6.9 and 6.11 present the autocorrelation (*ø*) for sessions 1 and 2, comparing all participant groups. Tables 6.10 and 6.12 show whether there is a significant difference between any of the coefficients. Results from session 1 show that autocorrelation is significant for all groups, demonstrating the presence of coherent response patterns. However, there are no significant differences between groups as shown in Table 6.10. The result is similar for session 2 whereby all groups demonstrate a significant autocorrelation coefficient within groups, but there is no significant difference between groups (see Table 6.12).

Table 6.9. Autocorrelation coefficients (*ø*) for all groups, session 1**.**

Session 1

Group	**Intercept**	***p* value**	***ϕ***	***p* value**	**Std D**
6-8	86.356	0.000***	0.142	0.002**	2.624
9-12	92.565	0.000***	0.402	0.000***	2.663
13-17	94.216	0.000***	0.454	0.000***	2.219
18+	102.465	0.000***	0.505	0.000***	2.414
Autistic	79.839	0.000***	0.397	0.000***	4.911

$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table 6.10. Testing significance between autocorrelation coefficients for all groups, session 1.

Session 1 - *p* values

	6-8	9-12	13-17	18+	ASC
6-8					
9-12	0.188				
13-17	0.088	0.746			
18+	0.063	0.548	0.746		
ASC	0.253	0.980	0.759	0.577	

$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table 6.11. Autocorrelation coefficients (*ø*) for all groups, session 2.

Session 2

Group	**Intercept**	***p* value**	***ϕ***	***p* value**	**Std D**
6-8	89.302	0.000***	0.167	0.003**	3.393
9-12	101.624	0.000***	0.469	0.000***	3.066
13-17	102.652	0.000***	0.516	0.000***	2.322
18+	108.569	0.000***	0.473	0.000***	3.055
Autistic	84.274	0.000***	0.476	0.000***	5.838

$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table 6.12. Testing significance between autocorrelation coefficients for all groups, session 2.

Session 2 - *p* values

	6-8	9-12	13-17	18+	ASC
6-8					
9-12	0.113				
13-17	0.051*	0.756			
18+	0.147	0.982	0.800		
ASC	0.154	0.970	0.819	0.988	

*p < .05. **p < .01. ***p < .001.

Tables 6.13-6.28 present autocorrelation coefficients and between-group significance tests for trials 1-8. The autocorrelation tables also contain intercept values which can be interpreted as the mean expectancy rating for that particular trial. There are no significant differences between the coefficients of autistic children and TD children and adults.

Table 6.13. Autocorrelation coefficients (ø) for all groups, trial 1.

Trial 1

Group	Intercept	*p* value	ϕ	*p* value	Std D
6-8	83.772	0.000***	0.08	0.101	2.877
9-12	83.112	0.000***	0.321	0.000***	2.83
13-17	84.949	0.000***	0.387	0.000***	2.646
18+	91.925	0.000***	0.457	0.000***	3.145
Autistic	77.943	0.000***	0.309	0.000***	5.781

*p < .05. **p < .01. ***p < .001.

Table 6.14. Testing significance between autocorrelation coefficients for all groups, trial 1.

Trial 1 - *p* values

	6-8	9-12	13-17	18+	ASC
6-8					
9-12	0.240				
13-17	0.107	0.701			
18+	0.063	0.457	0.677		
ASC	0.324	0.955	0.695	0.475	

$*p < .05$. $**p < .01$. $***p < .001$.

Table 6.15. **Autocorrelation coefficients (ø) for all groups, trial 2.**

Trial 2

Group	**Intercept**	***p* value**	ϕ	***p* value**	**Std D**
6-8	85.741	0.000***	0.113	0.044*	3.452
9-12	92.114	0.000***	0.349	0.000***	3.206
13-17	91.609	0.000***	0.448	0.000***	2.517
18+	100.952	0.000***	0.487	0.000***	3.22
Autistic	75.032	0.000***	0.401	0.000***	6.307

$*p < .05$. $**p < .01$. $***p < .001$.

Table 6.16. Testing significance between autocorrelation coefficients for all groups, trial 2.

Trial 2 - *p* values

	6-8	9-12	13-17	18+	ASC
6-8					
9-12	0.243				
13-17	0.070	0.549			
18+	0.060	0.438	0.807		
ASC	0.199	0.798	0.800	0.660	

$*p < .05$. $**p < .01$. $***p < .001$.

Table 6.17. Autocorrelation coefficients (ø) **for all groups, trial 3.**

Trial 3

Group	Intercept	*p* value	ϕ	*p* value	Std D
6-8	87.096	0.000***	0.151	0.009**	3.089
9-12	95.64	0.000***	0.41	0.000***	3.361
13-17	98	0.000***	0.461	0.000***	2.816
18+	107.628	0.000***	0.543	0.000***	3.554
Autistic	77.916	0.000***	0.405	0.000***	6.203

*p < .05. **p < .01. ***p < .001.

Table 6.18. Testing significance between autocorrelation coefficients for all groups, trial 3.

Trial 3 - *p* values

	6-8	9-12	13-17	18+	ASC
6-8					
9-12	0.187				
13-17	0.088	0.749			
18+	0.040*	0.424	0.592		
ASC	0.253	0.980	0.761	0.464	

*p < .05. **p < .01. ***p < .001.

Table 6.19. Autocorrelation coefficients (**ø**) **for all groups, trial 4.**

Trial 4

Group	Intercept	*p* value	ϕ	*p* value	Std D
6-8	88.602	0.000***	0.254	0.001**	3.696
9-12	95.904	0.000***	0.524	0.000***	3.756
13-17	99.372	0.000***	0.497	0.000***	2.885
18+	107.321	0.000***	0.516	0.000***	4.275
Autistic	84.129	0.000***	0.405	0.000***	6.702

*p < .05. **p < .01. ***p < .001.

Table 6.20. Testing significance between autocorrelation coefficients for all groups, trial 4.

Trial 4 - *p* values

	6-8	9-12	13-17	18+	ASC
6-8					
9-12	0.134				
13-17	0.160	0.853			
18+	0.161	0.960	0.901		
ASC	0.484	0.521	0.610	0.562	

**p* < .05. ***p* < .01. ****p* < .001.

Table 6.21. Autocorrelation coefficients (*ø*) **for all groups, trial 5.**

Trial 5

Group	**Intercept**	***p* value**	ϕ	***p* value**	**Std D**
6-8	85.486	0.000***	0.116	0.049*	3.595
9-12	95.148	0.000***	0.488	0.000***	3.549
13-17	95.123	0.000***	0.454	0.000***	2.643
18+	101.552	0.000***	0.363	0.000***	3.479
Autistic	83.687	0.000***	0.43	0.000***	6.587

*p < .05. **p < .01. ***p < .001.

Table 6.22. Testing significance between autocorrelation coefficients for all groups, trial 5.

Trial 5 - *p* values

	6-8	9-12	13-17	18+	ASC
6-8					
9-12	0.052*				
13-17	0.070	0.827			
18+	0.268	0.510	0.626		
ASC	0.161	0.759	0.898	0.760	

*p < .05. **p < .01. ***p < .001.

Table 6.23. Autocorrelation coefficients (ø) **for all groups, trial 6.**

Trial 6

Group	**Intercept**	***p* value**	***ϕ***	***p* value**	**Std D**
6-8	90.878	0.000***	0.197	0.006**	3.991
9-12	99.987	0.000***	0.513	0.000***	3.977
13-17	102.716	0.000***	0.479	0.056*	2.662
18+	109.011	0.000***	0.444	0.000***	3.761
Autistic	85.581	0.000***	0.5	0.000***	7.311

*$p < .05$. **$p < .01$. ***$p < .001$.

Table 6.24. Testing significance between autocorrelation coefficients for all groups, trial 6.

Trial 6 - *p* values

	6-8	9-12	13-17	18+	ASC
6-8					
9-12	0.087				
13-17	0.119	0.821			
18+	0.243	0.700	0.843		
ASC	0.154	0.942	0.905	0.782	

*$p < .05$. **$p < .01$. ***$p < .001$.

Table 6.25. Autocorrelation coefficients (ø) **for all groups, trial 7.**

Trial 7

Group	**Intercept**	***p* value**	***ϕ***	***p* value**	**Std D**
6-8	91.719	0.000***	0.244	0.001**	3.652
9-12	104.627	0.000***	0.499	0.000***	3.93
13-17	104.064	0.000***	0.567	0.000***	3.018
18+	110.845	0.000***	0.622	0.000***	4.479
Autistic	81.623	0.000***	0.52	0.000***	7.303

*$p < .05$. **$p < .01$. ***$p < .001$.

Table 6.26. Testing significance between autocorrelation coefficients for all groups, trial 7.

Trial 7 - *p* values

	6-8	9-12	13-17	18+	ASC
6-8					
9-12	0.164				
13-17	0.056	0.634			
18+	0.044*	0.438	0.975		
ASC	0.182	0.906	0.774	0.560	

*p < .05. **p < .01. ***p < .001.

Table 6.27. Autocorrelation coefficients (ø) **for all groups, trial 8.**

Trial 8

Group	**Intercept**	***p* value**	ϕ	***p* value**	**Std D**
6-8	90.299	0.000***	0.188	0.008**	4.156
9-12	106.397	0.000***	0.496	0.000***	3.858
13-17	107.349	0.000***	0.563	0.000***	2.86
18+	113.125	0.000***	0.514	0.000***	3.638
Autistic	84.915	0.000***	0.533	0.000***	7.446

*p < .05. **p < .01. ***p < .001.

Table 6.28. Testing signific**ance between autocorrelation coefficients for all groups, trial 8.**

Trial 8 - *p* values

	6-8	9-12	13-17	18+	ASC
6-8					
9-12	0.100				
13-17	0.030*	0.641			
18+	0.112	0.917	0.758		
ASC	0.107	0.837	0.857	0.922	

*p < .05. **p < .01. ***p < .001.

6.4 Chapter discussion and summary

This chapter combines results from chapters 3-5 so that key developmental trends in melodic perception can be investigated quantitatively. The mean rating scores provided by participants can be interpreted as markers for veridical expectations, which represent predictions for specific musical events. A series of ANOVAs examined between-group differences for sessions and trials for a) the melody as a whole; b) phrase A, and c) phrase B. The key findings in this chapter relate to differences between TD children and adults, and between autistic children and TD participants (children and adults).

As hypothesised in section 6.1.1 of this chapter, as participants grow older, they exhibit a stronger influence of veridical expectations which naturally results in the largest difference in mean ratings to occur between young children and adults. Differences between participant groups that are closer in terms of age emerge as the number of trial repetitions increases. For example, differences in mean ratings between 6-8- and 9-12-year-olds only occur in trials 7 and 8; differences in mean ratings between 6-8- and 13-17-year-olds occur in trials 3-4, and 6-8; and differences in mean ratings between 6-8-year-olds and adults occur during trials 2-8. These findings suggest that memory plays a key role in how melodic perception develops over both trajectories: age and time.

Results set out in this chapter support the hypothesis that ASC children differ from typically developing participants for an increasing number of trials as the age-gap widens. For example, autistic children’s ratings are significantly lower than TD children aged 9-12 during trials 3, 7 and 8. The variation between autistic children and 13-17-year-olds is more consistent, occurring during trials 3-4 and 6-8. Finally, the ratings of autistic children are significantly lower than adults in trials 2-8. Also, as hypothesised, there are no differences between children with ASC and TD children aged 6-8. Hence, veridical expectations are less influential in autistic listeners compared with typically developing children from 9+.

Separate analysis for phrase A and B reveals that between-group differences were more distinct for phrase A. This highlights firstly that within- and between-trial repetition is an important factor in the generation of veridical expectations. Secondly, it emphasises an important methodological limitation in that these findings are not replicated between phrases. Therefore, it would be sensible to aim to replicate aspects of this study using a broader range of musical contexts so that expectancy fluctuations are better understood.

7 Discussion

This thesis has been concerned with two objectives pertaining to the perception of melodic expectations in the context of repetition. The first is to investigate the influence of repetition on the interaction between schematic, veridical and within-group expectations in adult listeners. The second is to identify how the interaction between different forms of expectation evolves as a result of typical and atypical development in the context of familiar music. These objectives are informed by a plethora of psychological and musicological literature, with particular focus on the work of Meyer (1956), Huron (2006) and Ockelford (2006, 2012). Meyer proposed that musical patterns generate various predictions about what will ensue, and it is the thwarting of those predictions that generates pleasure during music listening (Meyer, 1956). This led researchers to question what happens when we can predict moments of 'surprise' leading to pleasure, resulting in the idea that the cognition of familiar music is underpinned by variants of expectation (Bharucha, 1987; Huron, 2006; Ockelford, 2006, 2012; Thorpe et al., 2012). This idea is explored in zygonic theory (e.g. Thorpe et al., 2012), which proposes that *schematic* expectations (a general indication of the future based on schematic probability), *within-group* expectations (a general indication of the future based on gestalt-based pattern continuation), and *veridical* expectations (a specific indication of the future based on direct repetition) interconnect.

Four research questions were formulated so that the objectives could be measured systematically. To recap, the research questions are as follows:

1. Does melodic repetition influence the relationship between schematic, veridical and within-group expectations cumulatively in ‘typical’ adults?
2. What are the normative age trends in children aged from 6-17 in terms of the development of schematic, veridical, and within-group melodic expectations, and how do those expectations interact in response to melodic repetition?
3. How does the ‘atypical’ development of children with high-functioning autism influence the interaction between schematic, veridical and within-group expectations in a repeated melodic context?
4. Is there a difference in the developing interaction between different forms of expectation between each participant group?

Participants were typically developing children aged 6-8, 9-12, and 13-17, typically developing adults, and children with high-functioning ASC. The participant groups were selected so that the interplay between various forms of expectation could be investigated at different stages of development. Each participant group underwent the same experimental procedure where they rated their perceived expectedness for each note in an 8x presented melody over the course of two sessions that were separated by seven days. Participants with additional needs were given additional task instructions prior to the experiment. Quantitative and descriptive analysis investigated a) the melody as a whole, b) phrase A, and c) phrase B. Analysis was similar for all participant groups, but the theoretical grounding varied depending on the research question. The discussion in this chapter is organised into a separate section for each participant group, each of which begins a table that summarises the results. Research question 1 provides a baseline, highlighting how schematic, within-group and veridical expectations operate in typical adult listeners. This informs research question 2, which investigates how this interplay progresses developmentally, which in turn informs research question 3 and 4, enabling comparisons to be made with children with ASC, and across all participant groups. The discussion relates to existing literature followed by an exploration of limitations for each participant group.

7.2 Adults

Table 7.1. Summary of results – adults.

Analysis type	Results	Interpretation
1. ANOVA: Trial repetition	(a) Significant increase in expectedness between sessions 1 and 2. (b) Significant influence of trial repetition. Post-hoc comparisons reveal a significant increase in ratings between trials 1-2, 2-3 and 5-6, and a significant decrease between trials 4-5.	(a), (b), (c), (d) Indicates a cumulative influence of repetition on expectations. (b), (c) The cumulative influence is affected by recency of stimulus presentation where expectations are 'reset' between sessions.
	(c) Phrase A: Significant influence of trial repetition. Post-hoc comparisons reveal a significant increase in ratings between trials 1-2 and 5-6 . (d) Phrase B: Significant influence of trial repetition. Post-hoc comparisons reveal a significant increase in ratings between trials 1-2, 2-3 and 5-6.	
2. Descriptive pitch-level analysis of phrase A	(a) Both sessions: Each major 2nd is rated as expected to a lessening degree with each trial. (b) Both sessions: Each major 3rd is rated as surprising to a lessening degree with each trial (except for trials 3 and 4 pitches 20-21, trial 6 pitches 3-4 in phrase A1.4, and trials 6 and 8 pitches 3-4 in phrase A1.2).	(a), (b) Demonstrates that even having been exposed to a pattern numerous times, participants' within-group expectations persist, but become weaker over time.
3. Descriptive pitch-level analysis of phrase B	(a) In the first trial, pitch 3 in phrase B2 receives lowest rating. This does not occur in trials 2-8. (b) Pitch 4 in phrases B1 and B2 (pattern disruption) are consistently rated as surprising.	(a) Pitch 3 in phrase B2 is the melody's lowest pitch. Participants are surprised during first trial, but have internalised and retained the information by the second trial. (b) May be due to the activation of within-group expectations for pattern continuation. Alternatively, it could be an expectation for a reverse transposition of phrase A. (c) Consistent surprise at pitch 4 in phrases B1 and B2 occurs despite an increasing influence of veridical expectations. This reveals resistant schematic expectations.

4. Rating distribution	(a) Rating distribution flattens with each trial – mean score decreases with each trial throughout session 1, resets between sessions, and decreases again throughout session 2. (b) Autocorrelation coefficient is significant within each trial, but there are no significant differences between each trial.	(a) Indicates a strengthening of veridical expectations over schematic expectations in response to repetition. (b) Significant within-group coefficient for each trial indicates that high ratings follow high ratings, and low ratings follow low ratings indicating consistency across all trials.

7.2.1 Research question 1

The key finding pertaining to adult participants is that schematic and within-group expectations are preserved in response to repetition, alongside a simultaneous increase in veridical expectations, which accords with the theoretical proposal (Huron, 2006; Thorpe et al., 2012) that the phenomenon of repeated listening to music is partly due to a dynamically changing relationship between various sources of expectation. In response to the research question, it is proposed that a) there is a cumulative effect of repetition on adult listeners' expectations; b) that does not lead to a saturation point after which repetition provides no additional information to the listener; c) but that is affected by recency. These three aspects are summarised followed by a discussion with reference to summary table 7.1, above.

7.2.2 Key finding 1a: cumulative expectations

As hypothesised in chapter 1, the present study demonstrates that repeated presentations of a phrase or group of notes results in a diminishing influence of schematic and within-group expectations and a strengthening influence of veridical expectations. As summarised in Table 7.1, section 2, the interaction between within-group and veridical expectations is cumulative, but to a lessening degree with each trial. The results also reveal that the cumulative effect is similar for phrases A and B, which suggests that repetition influences both phrases at a similar rate (change Table 7.1, section 2). This demonstrates a process of veridical encoding (Bharucha, 1987; Huron, 2006) in that between-group projections pertaining to a specific piece of music first exist in short-term memory and thereafter cross into long-term memory as a result of repetition (e.g. Neuhaus, Knösche, & Friederici, 2009).

7.2.3 Key finding 1b: saturation point

It is hypothesised in chapter 1 that the point at which veridical expectations no longer adjust represents the point at which listeners can fully predict what will come next, and this would be represented as a flatline whereby expectancy ratings sit at the maximum value. A specific number of repetitions at which this might occur was not estimated. The current results indicate that a saturation point was not met, since responses did not flatline. However, the results instead indicate that cumulative perceptual change in response to repetition may reach an asymptote; a position at which there is no longer an adjustment in the balance between schematic, within-group and veridical expectations, but where it is not possible for veridical expectations to entirely dominate. Saturation is defined in the Oxford English Dictionary as “the stage beyond which no more can be absorbed or accepted”, therefore, perhaps it is argued that listeners do not need to absorb 100% of a piece of music to predict future outcomes with a considerable degree of certainty, implying that the point beyond which new information is no longer absorbed may not necessarily lie at maximal probability.

7.2.4 Key finding 1c: recency

In accordance with the hypothesis in chapter 1, the current study’s results show that recency contributes to the ebb and flow of expectations, revealing that veridical expectations decrease in strength between sessions, and more quickly increase once the stimulus is re-presented in session 2 (see Table 7.1, section 1). Additionally, the consistent decline in phrase A’s expectedness between A1.2 and A1.3 (whilst listeners are presented with phrase B) indicates that the cumulation of within-trial veridical expectations is impacted by recency (see Table 7.1, section 2). These results accord with reports that listeners rest familiar pieces of music so that they can re-engage with ‘fresh ears’ (Greasley & Lamont, 2013; Margulis, 2014), implying that veridical expectations operate in working memory and long-term memory, enabling listeners to re-orient themselves with familiar pieces after having not listened to them for a period of time.

7.2.5 Interpretation of findings

It is proposed here that adults engage in a two-stage familiarisation process: a cumulative stage, and a cyclic stage. During the cumulative stage, repetition generates an increase in familiarity as information about a piece is cumulatively assimilated. The cyclic stage occurs once an individual is fully familiar with a piece and represents the rise and decay of veridical expectations as listeners rest and revisit pieces. The cumulative and cyclic stages are therefore moderated by recency - an anchor point upon which dynamic expectations fluctuate at the phrase and whole melody level. The concept of recency is generally not featured in the study of musical expectations, except for the zygonic model which holds that *recency* = the strength of expectation for a particular note that is influenced by its temporal positioning, reaching as far back as four notes (Thorpe et al., 2012). The zygonic model also holds that *adjacency* and *recency* combined interacts with the *between-groups* principle (where a repeated pattern will generate expectations that rapidly increase in strength as the notes unfold again) so that the strength of an expectation for a group of notes will increase more rapidly when it is heard again. The current findings establish that recency could be integrated into future modelling of familiar music listening as a representation of two stages of dynamic change in memory. For example, zygonic *between-group* projections could be integrated with *cumulative recency* and *cyclic recency* so that the strength of between-group projections is representative of the memory decay observed in this study.

The two-stage familiarisation process described above also echoes Margulis' adoption of Cone's 3-stage analysis of repeated listening (Cone, 1977; Margulis, 2014), wherein the first stage is fully sensorial during which the particular workings of a piece are absorbed, the second stage continues the process of orientation, and the third stage enables listeners to enjoy a piece with immersed enjoyment that does not require the processing of new information. Margulis also reports that peak intense engagement with a piece correlates negatively with analytic involvement (Wong and Margulis, 2008), suggesting that listening pleasure increases with familiarity. In other words, as veridical expectations become more dominant, listening pleasure may increase. This reinforces Meyer’s theory that the pleasure generated from the disruption of expectations is heightened when implications are strongest, and verifies the present results which suggest that in terms of real-world music listening, schematic expectations always share a portion of the cognitive resources, and that veridical expectations never completely dominate. Similarly, several priming studies have demonstrated the robustness of schematic expectations even when musical sequences are repeated (Bigand et al, 2005; Marmel, Tillmann & Delbé, 2010; Tillmann and Bigand, 2010). This interpretation also accords with the idea that music perception is guided by an ever-moving temporal window, as proposed by Bigand and Parncutt (1999) whereby musical tension is said to be influenced by a short perceptual window, rather than the entire structure of a piece. The Musical Tension Model (Farbood, 2012) also proposes that musical tension based on an *attentional window* – that extracts data from the current listening experience – and a *memory window* – that pertains to the listening experience immediately before the attentional window – whereby musical elements such as dynamics, pitch height, and harmony, combine to create a tension score that is re-evaluated every 250ms. This dynamic modelling of musical tension indicates a constraint on the attentional focus of listeners which persists in the context of familiar music listening, since the formation of expectations are based on continuous changes in the listening environment. This may account for why a saturation point is not necessarily reflected as ‘flatline’, rather, there may be a band of values at which a sufficient level of predictability leads to perceived saturation in listeners.

7.2.5 Questionnaire items

As discussed in chapter 3, a significant difference was found between the ratings of males and females. This relates to Thorpe et al.'s (2012) finding that males gave significantly higher confidence ratings about their predictions compared to females, which increased to twice that of females over the course of the experiment. It is possible that the gender differences in the present study indicate that male respondents are more confident of their expectations that females. Thorpe and colleagues (2012) speculate that their results could be due to differences in hemispheric activity during music information processing, where music-syntactic processing occurs bilaterally in females and with a right hemispheric dominance in males (Koelsch, Maess & Grossman et al., 2003). Conversely, Miles et al. (2016) found that females recognised familiar melodies significantly faster than males in a novel/familiar melody discrimination task, although there was no difference in accuracy of performance between males and females. The authors suggested that this is consistent with previous findings that females tend to exhibit enhanced episodic memory performance – a memory process which is linked to the retention of explicit knowledge as well as the learning and binding of arbitrary bits of information. The difference between methods should be considered, as for example, it may be the case that males exhibit more confidence than females in rating paradigms, which is not perceptible in studies that employ discrimination tasks.

An alternative explanation for the gender difference is the imbalance of formal and informal instrumental playing between males and females as depicted in chapter 3 Figures 3.6 and 3.7. However, a regression model confirmed the null hypothesis that months of formal instrumental training was not a significant predictor. Other underlying factors that were not accounted for in the questionnaire could relate to the participant's age at which they underwent formal music training (Penhune, 2011), and the type of formal training i.e. whether or not their training took place at a music conservatoire. In hindsight, this section of the questionnaire could have been better formulated to include those additional insights. As for the questionnaire section on weekly music listening, it is not expected that adults who have a fully developed understanding of Western music would exhibit differences on the rating task. On the other hand, children are still piecing together the various structural elements that constitute music, therefore it is possible that this variable will have more of an impact on the younger participants (Trainor & Trehub, 1994; Bigand & Poulin-Charronnat, 2006).

7.2.6 Limitations

It is important to outline the limitations of the study to ensure that interpretations and conclusions are well constructed. Self-selection of musical pieces is not represented in this thesis, therefore some results discussed here may be different in real-world listening, but perhaps not to the detriment of the study. Although a 'saturation point' may theoretically be reached more quickly if a listener can predict what they will hear through self-selection, the current results demonstrate that schematic expectations for a simple monophonic melody are robust throughout eight repetitions. Greater musical complexity as experienced in real-world listening is likely to generate increased robustness, since it would take a greater amount of repetition for veridical expectations to dominate. Moreover, the number of times an individual hears a piece is unknown and would therefore be difficult to represent in any study, although the interplay between variants of expectation in response to repeated listening can still be predicted from the current results. Therefore, despite methodological constraints, real-world application of the current results is plausible.

7.2.7 Typically developing adults: summary

In summary, research question 1 addresses the relationship between schematic, within-group, and veridical expectations in response to a repeating melody, with particular focus on whether repetition affects expectations cumulatively, and whether this is influenced by recency of the repetition. The results show that repetition influences adults' expectations at the trial and phrase levels. Specifically, veridical expectations increase in dominance throughout session 1, reduce during the 7-day rest between sessions, and increase more quickly during session 2. Within each session, the influence is cumulative which demonstrates a process of structural integration in memory. The decline in veridical expectations followed by a sharper increase in session 2 also indicates absorption of melodic patterning into long-term memory. This can be expressed in terms of a two-stage listening process, where listeners undergo a cumulative stage of familiarisation followed by a cyclic stage where memory rises and decays as listeners rest and revisit pieces. The concepts of cumulative recency and cyclic recency are proposed as key factors to be integrated into future cognitive models of musical understanding. Furthermore, it appears that schematic expectations always share a portion of the cognitive resources as suggested by an asymptote which explains that explicit recognition of something can never fully override automatic schematic processes that reside in long-term memory. This may help to explain why repeated music listening increases liking for pieces since musical events that do not conform to schematic expectations may retain an element of surprise (Madison & Schiölde, 2017; North & Hargreaves, 1997), and aligns with Huron's example of watching a door slam shut but always being surprised by it on some level (Huron, 2006, p.6).

7.3 Typically developing children

Table 7.2. Summary of results – typically developing children.

Participant group	Analysis type	Within-group results	Interpretation
Children aged 6-8	**1.** ANOVA: Trial repetition *(section 4.3.2)*	(a) No significant influence of whole melody trial repetition. (b) No significant influence of phrase A trial repetition or phrase B trial repetition.	(a), (b) No evidence of between-trial veridical expectations.
	2. Descriptive pitch-level analysis of phrase A *(section 4.4.1)*	(a) Identification of a rating pattern with some inconsistencies: minor 2nd is expected; major 3rd is surprising.	(a) Influence of Gestalt-based long-term schematic expectations for 'adjacency', which pertains to two pitches. (a) Influence of within-groups is unclear. (a) No evidence of cumulative veridical expectations at phrase level.
	3. Descriptive pitch-level analysis of phrase B *(section 4.4.1)*	(a) No identifiable rating pattern in session 1 except for a moderately consistent expectation for closure. (b) Moderately consistent expectedness for descending major 2nd scale in session 2, phrase B1. (c) Consistent ratings of expectedness for phrase ending in session 2, phrase B1. (d) Pitch 3 (in phrase B2) continues a descending pattern of major 2nd intervals but is consistently rated as surprising.	(a), (b) Ratings for phrase B are less consistent than for phrase A, suggesting that phrase B is perceived as more complex. (a), (c) Consistent expectation for closure indicates schematic expectation for tonal stability. (d) Low rating for pitch 3 in B2 suggests an influence of schematic expectations for pitch range, whereby a particularly low pitch has a low probability. Could also be an influence of contour, but not possible to distinguish between the two.
	4. Rating distribution *(section 4.4.1)*	(a) Rating distribution does not alter systematically in response to trial repetition. (b) Autocorrelation coefficient is significant for trials 3-8, but no significance between trials.	(a) Irregular change in rating distribution supports the finding that veridical expectations are weak or absent. (b) Intercept strengthens over time indicating strengthening of veridical expectations.

Children aged 9-12	**5.** ANOVA: Trial repetition *(section 4.4.2)*	(a) Significant influence of whole melody trial repetition. (b) Post-hoc tests show a significant increase in ratings between trials 1-2, 2-3 in session 1, and 5-6 in session 2. (c) Significant influence of phrase A trial repetition and phrase B trial repetition. (d) Post-hoc tests for phrase A show significant difference between trials 1-2 and 2-3 in session 1, and 5-6 in session 2. (e) Post-hoc tests for phrase B show significant difference between trials 1-2 in session 1 and 5-6 in session 2.	(a) Trial repetition influences expectations. (b), (d), (e) Veridical expectations are influential early on in each trial, suggesting that children are most sensitive to melody repetition after one or two presentations and that this stabilises after the third presentation. (b), (d), (e) No evidence of cumulative veridical expectations at phrase level.
	6. Descriptive pitch-level analysis phrase A *(section 4.4.2)*	(a) Identification of rating pattern with some inconsistencies: major 2^{nd} expected, and major 3^{rd} surprising (more consistent in session 2).	(a) Influence of Gestalt-based long-term schematic expectations for 'adjacency', which pertains to two pitches. (a) Influence of within-groups is unclear. (a) No evidence of cumulative veridical expectations at phrase level.
	7. Descriptive pitch-level analysis phrase B *(section 4.4.2)*	(a) Ratings for phrases B1 and B2 are distinct. (b) B1: Consistent surprise at melodic continuation. (c) B1: Phrase-ending is expected throughout all trials, with more consistency than 6-8-year-olds. (d) B2: penultimate interval is consistently expected (e) B2: Ratings for final interval are inconsistent. (f) B2: Pitch 3 in phrase B2 is consistently rated as surprising.	(a), (b), (e) Perception of phrase B is maturing but still underdeveloped. (c) (d) (e) Influenced by tonal stability and closure, but still underdeveloped. (b), (d), (f) Sensory influence of prominent low register, indicating recognition of global pitch relationships.
	8. Rating distribution *(section 4.4.2)*	(a) Rating distribution of aggregated means decreases non-linearly throughout trials 1-8 (steepest change occurs in session 1). (b) Autocorrelation intercept increase with each trial.	(a), (b), (c) A flattening rating distribution in response to repetition indicates developing influence of veridical expectations.

		(c) No significant differences in autocorrelation coefficient between trials.	
Children aged 13-17	**9.** ANOVA: Trial repetition (*section 4.3.2)*	(a) Significant influence of whole melody trial repetition. (b) Post-hoc tests show a significant increase between trials 1-2 and 2-3 in session 1, and a significant increase between trials 5-6 in session 2.	(a), (b), (c), (d), (e) Veridical expectations are influential early on in each trial. (e) Veridical expectations are influenced by recency.
		(c) Significant influence of phrase A trial repetition and phrase B trial repetition. (d) Post-hoc tests for phrase A show a significant difference between trials 1-2 and 2-3 in session 1 and between trials 5-6 in session 2. (e) Post-hoc tests for phrase B show a significant difference between trials 1-2 and 2-3 in session 1, and between 5-6 in session 2.	
	10. Descriptive pitch-level analysis phrase A *(section 4.4.3)*	(a) Identification of a rating pattern, where the major 2nd is expected, and the major 3rd is surprising (a few inconsistencies).	(a) Phrase A repetition has a cumulative influence that is affected by recency. Despite the cumulation, schematic and within-group expectations persist.
	11. Descriptive pitch-level analysis phrase B *(section 4.4.3)*	(a) Phrases B1 and B2 are consistent, yet distinct. (b) B1: influenced by tonal stability and closure with more consistency than younger groups (c) B2: influenced by tonal stability and low register. (d) Pitch 3 in phrase B2 is consistently rated as surprising.	(a), (b), (c) Developed perception of phrase B due to age, but no evidence of cumulative influence. (a), (b), (c), (d) This group fluctuates between all three forms of expectation depending on various melodic features - fluctuations are consistent with each trial repetition.

	12. Rating distribution *(section 4.4.3)*	(a) Rating distribution decreases linearly from trials 1-4, is reset between trials, and continues to decrease throughout trials 5-8. (b) Autocorrelation coefficient intercept increases in response to trial repetition.	(a), (b) A systematic influence of veridical expectations that is influenced by recency. (b) Indicates increasing strength of veridical expectations.

7.3.1 Research question 2

The second research objective of the present thesis is to ascertain how schematic, within-group and veridical expectations develop in typically developing children from age 6-17, in response to repeated presentations of a melodic stimulus. The interaction between the three forms of expectation as children grow older is indicated by the presence of a) a cumulative response to repetition; b) whether recency of stimulus presentation is influential, and c) whether listeners reach a point of saturation after which stimulus repetition provides no additional information. The main finding to be discussed here is that, in terms of age-related development, schematic and within-group expectations emerge prior to veridical expectations. This is underpinned by three aspects to be discussed: age-related developmental progression where children first attend to single elements followed by connections between elements; a shift from absolute to relative perception; and implicit learning via exposure. The following sections discuss this finding and its implications for music and memory research with support from key literature that was presented in chapter 1, and with reference to Table 7.2.

7.3.2 Key finding 2a: age-related progression from single elements to connected elements.

As children grow older, their focus moves from pairs of notes, to isolated groups of three or more notes, to connected groups of notes which supports the hypothesis that was outlined in chapter 1. This is reflected in the quantitative and descriptive results that were presented in chapter 4. Results indicate that children as young as 6-8 years exhibit expectations that stem from the basic principle of pitch proximity, which steadily increases in reliability through to maturation during adolescence (see the increasingly consistent ratings for phrase A summarised in Table 7.2. sections 2, 6, and 10; and Table 7.2. section 5). Expectations that stem from more complex structures comprising two or more successive intervals do not emerge until age 9-12 and become more consistent as children grow older (summarised in Table 7.2. sections 3, 7, and 11). Furthermore, the absence of between-trial veridical expectations in 6-8-year-olds implies that the capacity to make between-group connections is still developing. At age 9-12 and 13-17, between-trial veridical expectations occur early on during each session, and they also occur within-trials at age 13-17 (see Table 7.2. sections 9 and 10). This supports the claim that the cognition of single elements precedes connected elements. However, this pattern is not observed in ratings for phrase B, revealing that complex aspects of melody perception might still be developing during adolescence (Table 7.2. section 11). The development of pitch relations in children beyond age 11 are not well known (Hargreaves & Lamont, 2017), therefore these results highlight fruitful avenues for future exploration.

7.3.3 Key finding 2b: age-related progression from absolute to relative perception

It was also hypothesised in chapter 1 that expectations will stem from low level information prior to high level information. In accordance, the results show that children attend to absolute melodic features before they focus on more complex features. This is supported by descriptive and quantitative analysis from chapter 4 of this thesis. Children in all three age groups are consistently surprised at the lowest pitch in the stimulus (see Table 7.2. sections 3, 7, and 11) even despite the presence of veridical expectations that pertain to that particular phrase (see Table 7.2. section 4). This indicates that a salient pitch (e.g. a pitch that lies outside the melody's typical range) generates a default bottom-up processing strategy that occurs when no pre-existing schema is available, reinforcing the notion that absolute perception come first in development. Furthermore, expectations for closure are evident in all age groups which increases in consistency as children grow older (see Table 7.2. sections 3, 7, and 11). These findings reflect reports that pitch proximity and an understanding of tonality are basic perceptual processes from which more complex links grow (Eerola et al., 2006; Eerola, 2016). Perception of closure requires the processing of relational melodic information that extends across several consecutive pitches, therefore, as younger children are less reliable at forming this expectation (see Table 7.2. section 3a and 3c), it is suggested that they do not rely on relational information in the same way as older listeners.

7.3.4 Key finding 2c: implicit learning from exposure

As musical knowledge is generally implicit, the role of mere exposure should also be considered as an influence on expectations. The current findings fit in with the proposition that implicit knowledge may be accumulated in the form of fragments that are facilitated by pre-existing schemas (Rohrmeier & Rebuschat, 2012). Evidence of short-term and long-term implicit learning is revealed by a systematic increase in expectedness during session 1, a decrease between sessions, and a sharper increase in expectedness during session 2 (Table 7.2. sections 1 and 2). This is more pronounced with each age-bracket increase, demonstrating long-term implicit learning scaffolded by common structures learned via exposure. This is also supported by the questionnaire results presented in chapter 4 section 4.5 which reveal that sensitivity to repetition during session 2 is predicted by age category. Although learning can be generated from exposure alone, intentional learning can further enhance cognition at each developmental stage. For instance, it is reported that musical training but not age enhances 6-11-year-olds' performance in recognising the difference between subtle and marked incongruous cadences (James et al., 2012), and that complex pattern perception such as the recognition of inversions is only acquired through intentional learning (Kuhn & Dienes, 2006). The current study indicates that even though intentional learning might enhance cognition and perception, that it is constrained by developmental stages that are loosely based on age.

7.3.5 Interpretation of findings: music development

The present results extend the findings presented by several key studies in childhood musical development. Firstly, Schellenberg et al., (2002) report that age is positively correlated with perceptual complexity, concluding that expectations based on pitch proximity for two adjacent pitches emerge prior to those based on a minimum of three consecutive pitches such as pitch reversal. The authors interpret their findings as a shift in melodic perception from “global processing based on contour, to local processing of specific intervals between two adjacent notes, to more detailed local processing of more than two notes” (Schellenberg et al., 2002, p.532), concluding that the development of expectations is due to memory improvement, mere exposure, and learning. The current results echo that of Schellenberg et al. (2002), as described in key findings *2a*, *2b*, and *2c* above, but instead suggest that pitches are first recognised in their most basic sensory form before they can be related to neighbouring pitches. This does not repudiate the necessity of contour in auditory perception, since it is integral in speech development from infancy (Zatorre & Baum, 2012), and is thus active throughout the lifespan. However, in terms of the construction and projection of melodic expectations onto future outcomes, it is proposed here that contour is not a primary cue (Halpern & Bartlett, 2010).

Voyajolu and Ockelford (2016) also report that age correlates with increasingly complex stages of musical engagement that relate to the ‘levels’ set out in the *Sounds of Intent* framework of musical development whereby children first attend to short motifs, eventually linking them together as longer melodic narratives, and connecting these with global structural features such as tonality, harmony, and tempo (refer to chapter 1 for a description of the framework and levels). However, the order in which expectations might develop, and the age at which they first appear are different in the present study. It is likely that different methods generate different findings. For example, Voyajolu and Ockelford’s method investigates independent sound-making driven by *internal* creativity, whereas the present study's rating paradigm requires children to match internal predictions with an *external* source and make probability-based judgements. The age discrepancy between the two studies may also imply a process of development that occurs on a continuum that extends from the internalisation to the externalisation of expectations, suggesting that the current results reflect more fully developed processes from which expectations arise.

In terms of the perceptual strategies employed by children of increasing age, the current results echo those presented by others. For instance, Stalinski and Schellenberg (2010) propose an absolute to relative developmental trend in the perception of pitch, observing that 5-7- year-olds attend more closely to absolute pitch cues, as do 8-9-year-olds but to a lesser degree, 10-12-year-olds attend to both relative and absolute pitch cues, and adults attend more closely to relative pitch, suggesting that listeners depend less on surface features as they grow older and have learned that relative cues alone are sufficient for melody cognition. The age differences are similar to the current findings in that 6-8-year-olds' expectations are influenced by sensory cues such as temporal proximity of pitch (see Table 7.2. sections 1-4), which shifts to a more complex perception in adulthood that also includes relational pitch cues (Table 7.2. section 11). Similarly, Costa-Giomi (2003) reports that during a series of chord discrimination tasks following training in harmonic understanding, 6-year-olds direct their attention to individual features of melody such as pitch, rhythm and contour, whereas older children at around eight years direct their attention toward harmonic progression and can group pitches according to the underlying harmony. Additionally, Schellenberg, Poon and Weiss (2017) examined long-term memory for melodies (recognition of twice heard melodies after a 10-minute delay) in children aged 7-8, 9-10, and adults, and found that accuracy of memory recognition improved systematically with age, which is indicative of memory development due to more efficient processing. In language, the learning of rules and principles enables readers to non-consciously complete missing letters in words, and missing words in sentences (Healy, 1976; Drewnowski & Healy, 1977), and the understanding of absolute numbers emerges prior to the understanding of how numbers relate to each other (Michie, 1985). Hence, many studies support the proposal that children first perceive melody in terms of its concrete cues before they can begin to utilise more resourceful processing methods that rely on relational cues. Similarly, it is reported that adult listeners can recognise once-heard melodies one month later (Peretz, Gaudreau, & Bonnel, 1998), and adults' memory for novel melodies is consolidated after only two presentations, where memory for a melody that was presented in a different key was better remembered after a 7-day delay compared to shorter delays of one day or ten minutes, indicating that once short-term memory for key declined, relational properties were maintained for at least one week (Schellenberg & Habashi, 2015). Dowling and Tillmann (2014) propose that the binding of melodic elements into relational structures occurs during encoding of ongoing music and alongside integration with pre-existing long-term schematic representations, which supports the notion that relative processing enhances memory.

7.3.6 Interpretation of findings: general memory development

The developmental progression demonstrated in the current study can be accounted for by changes in working memory and long-term memory that occur in early childhood and continue through adolescence and into adulthood. These aspects of memory are necessary for melodic information to be encoded, retained in long-term memory and thus remembered and recognised or recalled later (Baddeley, 1986; Baddeley & Hitch 2000). It is acknowledged that various subcomponents including span, processing efficiency, and maintenance contribute to the operation of working-memory and that these undergo developmental changes which underpin melodic expectations. For instance, it is proposed that the brain holds a limited number of items in working memory which increases in span throughout childhood and matures between the ages of 13-18 (Bayliss, Jarrold, Gunn, Baddeley, & Leigh, 2005; Cowan et al., 2010; Cowan et al., 2012). This accounts for the present finding that 6-8-year-olds attend to shorter sequences of notes compared to older children, which also explains why the youngest children are not yet sensitive to complex melodic patterning. This supports finding 2*b*, in that developmental changes shift from the sensory to the complex as a result of advances in memory capacity and efficiency.

The amount of information that can be absorbed and maintained in memory has also been correlated with the speed at which it is processed (Case 1985; Case, Kurland, & Goldberg, 1982; Kail, 1991; Kail & Salthouse, 1994; Towse et al., 1998), and working memory storage has been described as the amount of time passed during processing and the amount of time left for rehearsal (Unsworth et al., 2009). Similarly, Barrouillet, Gavens, Vergauwe, Gaillard, & Camos (2009), note that developmental differences in working memory are due differences in processing speed, rate of decay, as well how efficiently decaying memories are reactivated. They demonstrated that when children are engaged in processing, the reactivation process begins at seven years of age and continues to increase in its efficiency until late adolescence. This may explain why veridical expectations are not observed in the ratings of 6-8-year-olds in this study, because memory reactivation is in the earliest stages of development. This also accords with section *2b* in this discussion, whereby younger children may prefer to attend to surface features of melody rather than relational constructs, since they are not yet reactivating information in their working memory efficiently enough for the creation of long-term memory schemas.

Having reviewed developmental differences in long-term memory, Ofen and Shing (2013) also confirm that children weight absolute information more so than adults. They speculate that children compensate for an underdeveloped memory system by relying on perceptual information. Interestingly, they suggest that semantic memory development could be underpinned by the dismantling of episodic memories into abstract memories that can then be flexibly manipulated to create new concepts, which, in terms of expectations would imply that within-group expectations would emerge first, since they are based on current perceptual information, followed by veridical expectations which pertain to pitch relations occurring between groups, followed by the formation of abstract schematic expectations. This also coordinates with the observations of Voyajolu and Ockelford (2016) which imply that within-group expectations emerge first, followed by veridical and then schematic expectations, which differs to the current study. However, it is proposed that veridical expectations can be regarded as semantic or episodic memories, since they represent knowledge of music as well as an ability to connect that knowledge to a personal experience (Huron, 2006, p.225), which therefore indicates that the development of schematic, within-group and veridical expectations may not be linear. These various interpretations also demonstrate that more research is required to fully understand the predictive processes that the current study has highlighted.

Taken together, the above studies show that the consolidation of individual bits of information into coherent groups are fundamental for remembering melody in typically developing listeners, and that a contextual reminder is sufficient for memory representations to be activated during a recognition task. If connections between musical elements are formulated once absolute features decay from memory, this may account for why veridical expectations are subordinate in 6-8-year-olds, since their perception is weighted by absolute processing and are thus in the early stages of making such connections. Children aged 9-12 and 13-17, however, are more likely to perceive melody in terms of its relational properties, and this seems to explain why they exhibit improved long-term memory in the current experiment. Finally, it is implied that implicit learning from exposure correlates with an individual's cognitive and perceptual abilities, which underpins the two key findings discussed in *2a* and *2b* where it is proposed that implicit knowledge of melodic patterning is acquired first from absolute cues, followed by relational cues where chunks of melody are assimilated, which increase in size and are connected with other chunks. This accords with the notion that cognitive developmental stages are bracketed, meaning that children absorb a limited amount of information even in response to repetition (akin to a saturation point) which can be enhanced by intentional learning, after which deeper learning can only be achieved when they reach the next developmental stage, much like the levels set out by Voyajolu and Ockelford (2016).

7.3.5 Limitations

As discussed in the methods chapter, the limitations pertaining to this participant group are primarily due to age-related task understanding. Inevitably, some children may have experienced issues with comprehension and concentration, and this was accounted for in the procedure, where extra time was given to the youngest participants. The results integrate well within existing developmental psychology literature, which supports the interpretation that children successfully engaged with the task as intended. It would be interesting in future studies to use a larger sample size for each of the age groups, however, the present data still presents a valid contribution.

7.3.6 Typically developing children: summary

The present results accord with the hypotheses, revealing that the balance between schematic, within-group and veridical expectations alters as children grow older, representing increasingly complex stages of musical engagement. It is theorised that the change in expectations results from three aspects pertaining to memory: development of working memory such as memory span, cognitive capacity, processing efficiency, and memory reactivation; changes from absolute to relative processing that supports the development of long-term memory consolidation; and implicit learning from exposure. The present study broadens the profile of expectations by integrating existing theory with new empirical observation, bridging the gap between research on expectations and general memory development, and offering a detailed account of how general and specific expectations underpinned by short-term and long-term memory influence melody perception at various developmental stages in typically developing children. Furthermore, the adaption of expectations in response to repeated listening over two separate sessions further contextualises expectations in terms of developmental cognition and perception, since it simulates the flux of expectations that might occur in real-world listening. Finally, these results highlight children's perceptual characteristics gleaned from behavioural data which can be used to inform predictive models of repeated listening to music from early childhood through to adulthood, which has not previously been achieved.

7.4 Children with high-functioning ASC

Table 7.3. Summary of results – autistic children.

Analysis type	Results	Interpretation
1. ANOVA: Trial repetition *(section 5.3)*	(a) No significant influence of whole melody trial repetition. (b) No significant influence of phrase A or phrase B trial repetition.	(a), (b) No evidence of between-trial veridical expectations. This could be due to a local processing bias.
2. Descriptive pitch-level analysis of phrase A *(section 5.4)*	(a) Most major 2^{nd} intervals are rated as expected in session 1 (except for two ratings in trial 4). The result is similar in session 2 but with less consistency. (b) In first half of each trial, major 3^{rd} intervals are consistently rated as expected for pitches 7-8 (except trial 5). (c) In second half of each trial, major 3^{rd} intervals rated as unexpected with moderate consistency.	(a) Perceived expectedness for major 2^{nd} intervals might be representative of pitch proximity, however this is only apparent for phrase A, therefore this could also represent an influence of melodic contour, since all major 2^{nd} intervals in phrase A are ascending. Generally, children exhibit pockets of consistent responses among random ratings. (b), (c) ASC children's ratings hint at a difference in perception between the first and second halves of each trial. Indicative of sensitivity to melodic narrative from start to end, but a disinterest in trial repetition. Demonstrates a towards local processing with intact global processing.
3. Descriptive pitch-level analysis of phrase B *(section 5.4)*	(a) B1: Consistent surprise at melodic continuation from pitches 203 phrase B1 in all trials except 1 and 3. (b) B2: Consistent surprise at melodic continuation from pitches 2-3 phrase B2 in all trials except 3 and 5. (c) B1: phrase ending (pitches 4-5) is expected in trials 1, 3, and 6-8 (d) B1: phrase ending (pitches 4-5) is expected in all trials.	(a), (b) There is no rating pattern that encapsulates the whole phrase, but there are consistent ratings for groups of 3-4 adjacent notes. (a), (b) Melodic contour is more dominant than within-group expectations for pattern continuation. (c), (d) Expectations for closure based on tonal stability (schematic expectations) are more dominant than contour.
4. Rating distribution *(section 5.4.3)*	(a) Rating distribution of means does not alter systematically in response to trial repetition. (b) Autocorrelation intercept moves very little in response to trial repetition when compared with TD participants.	(a), (b) The ratings of autistic children become more regular with repetition, but do not increase in overall expectedness. expectations and not due to veridical expectations.

7.4.1 Research question 3

The third research objective of this thesis is to ascertain how schematic, within-group and veridical expectations operate in children aged 8-17 with high-functioning autism in the context of melodic repetition, framed by zygonic theory. In the above discussion of typically developing adults and children, the influence of repetition on expectations is identified. However, this is not observed in the ratings of autistic children. Hence, as hypothesised, children with autism perceive music differently to those who are typically developing. Specifically, they exhibit a bias towards processing local melodic information whilst still maintaining an ability to cognise global information. Few studies have examined global melody perception and thus melodic expectations in autism, and fewer still have assessed melody perception in the context of repetition. Therefore, this research contributes new knowledge about how auditory pattern perception evolves in response to repetition in listeners with autism. Three key aspects are discussed below, with reference to Table 7.3.

7.4.2. Key finding 3a: no influence of repetition

The first key finding is supported by descriptive and quantitative analysis and observes that within-trial and between-trial expectations are not influenced by repetition (Table 7.3. sections 1, 2b, 2c, 4a, and 4c), therefore there is no evidence of cumulation, recency or saturation in response to repetition. Furthermore, the established rating pattern that was observed in TD participants of all ages discussed in chapters 3 and 4 is not observed in ASC children, again implying little or no relationship between repetition and ASC children's ratings. It is also implied from the descriptive analysis (Table 7.3. sections 2 and 3) that consistent ratings across trials do not capture clear sections of phrases that form an intended Gestalt, except for the expectation for closure during phrase B. This seemingly atypical rating style may indicate differences in attention or working memory.

Overall, the finding that within-trial and between-trial repetition is not influential indicates that veridical expectations and within-group expectations are subordinate in ASC children.

7.4.3 Key finding 3b: a sensory bias

The second key finding is that autistic children attend closely to melodic contour. This is supported by descriptive analysis, summarised in Table 7.3, section 2a. The major 2^{nd} intervals in phrase A are perceived as expected, but the major 2^{nd} intervals in phrase B are not. Considering that all major 2^{nd} intervals in phrase A are ascending (in the same direction as the ratings), an influence of melodic contour rather than pitch adjacency is implied. Furthermore, melodic continuation is consistently rated as surprising during the second interval in phrases B1 and B2, indicating that melodic contour is consistently more dominant than within-group pattern continuation (see Table 7.3. section 3a and 3b). Conversely, typically developing participants regard the second interval in phrase B2 (pitch 24) as particularly surprising due to the low pitch, but they don't perceive the same interval in B1 (a fifth scale step higher) as surprising. This observed difference between participant groups reinforces the interpretation that autistic children are notably more influenced by melodic contour than their TD peers. This finding was not predicted, however, it highlights a key aspect of perception in autism that deserves attention in future studies of melody perception.

7.4.4 Key finding 3c: intact global processing

The third key finding is that autistic children also attend to structural information pertaining to tonality, and temporal placement, and this is supported by descriptive analysis. Autistic children consistently rate the final descending interval in phrases B1 and B2 as expected (Table 7.3. section 3c and 3d), indicating that they are influenced by closure which is underpinned by tonal stability. Awareness of the melody's tonal structure and unfolding narrative indicates the assimilation of global melodic information, and thus the activation of schematic expectations for tonality and closure.

7.4.5 Interpretation of findings

The present findings suggest that autistic children display a different balance of schematic, within-group and veridical expectations compared with children and adults who are typically developing. Most striking and unique to ASC participants is that they do not alter their ratings in response to phrase or melody repetition, yet they are simultaneously aware of the melody's structure. This demonstrates perceptual characteristics that are not evident in TD listeners, where autistic children focus on local features such as pitch values, intervals between pitches and their direction, whilst absorbing global information about the melody's tonal structure and phrase boundaries and integrating that into their predictions about upcoming salient parts of the melody. This suggests that even when a melody becomes familiar, schematic expectations stay dominant, unlike the increasing influence of veridical expectations exhibited by TD children and adults. An additional characteristic of melody perception found in autistic children is that they are influenced by the melody's contour, thereby highlighting the importance that sensory information plays in autistic perception. It is unclear as to whether contour imitation is representative of their expectations, however it evident that contour is influential.

These findings can be discussed within the context of two significant models of perception in autism; namely the Weak Central Coherence (WCC) model (Happé, 1999) and the Enhanced Perceptual Functioning (EPF) model (Mottron, 2000; Mottron et al., 2006), both of which were presented in the literature review. To recap, both postulate that people with autism have enhanced sensory processing, but each theory accounts for it in different ways. First, the WCC model suggests that local processing in autism is due to a 'cognitive style', whereby perception occurs along a continuum of global coherence from weak to strong (Happé and Frith, 2006), whereas the EPF model proposes that autistic people exhibit a profound difference in brain organisation (Mottron et al., 2006). Of the few studies that have assessed high-level music processing in autism, all have confirmed that global coherence is intact (Heaton et al., 2007; Quintin et al., 2013; Stanutz et al., 2014). Although the present study does not demonstrate *enhanced* perceptual functioning, it does reveal a bias towards local processing. It also reveals that ASC children have the capacity to process tonal and phrase structure at clear boundary points, as proposed by key finding *3c* above. Accordingly, the current study supports *Principle 1* of the EPF model (Mottron et al., 2006), demonstrating that autistic children can process global musical information whilst still attending most closely to local features. Additionally, the present findings also support *Principle 5* which states that higher-order processing is not mandatory for those with autism, demonstrating that although autistic children have been 'primed' with prior knowledge (i.e. repeatedly presented with a melodic stimulus), they still operate with a local precedence.

The study of expectations may help to clarify why there are perceptual differences between autistic and typical listeners. As contextualised by zygonic theory, the current findings indicate that, uniquely to autistic children, within-group and veridical expectations are subordinate, and that long-term schematic expectations (such as tonality) and sensory influences (such as contour and absolute pitch) are more dominant, and that this balance does not change in response to stimulus repetition. It is proposed here that these differences are due to variation in memory function and perceptual strategies. Two examples are presented. Firstly, autistic listeners have the capacity to implicitly learn the tonal properties of a specific stimulus and that this informs their predictions about the stimulus at distinct boundary points (e.g. the end of phrases B1 and B2). It is thus argued that the 'online' learning and projection of tonal knowledge within a specific piece of music or melody is possible because it is based on a deep-seated framework that consists of clear structural rules. Secondly, autistic children absorb information about the internal patterning of the stimulus, but conversely this does not inform their predictions about the melody's trajectory with any consistency. Therefore, some aspects of melodic information are processed using top-down strategies, but this might be constrained to rule-based features such as tonality. Conversely, melodic features that are driven by within-group and veridical expectations are less easy for autistic children to process. In other words, the perceived predictability of a melody may influence the perceptual strategies employed by autistic listeners, where weak implications lead to sensory processing and thus are not projected onto current listening, and strong implications lead to schematic processing which are projected onto current listening. This would suggest that *certainty* is a key factor that influences expectations in children with autism, and thus would be a significant aspect of models of musical understanding in autism. High certainty predicts that projections will be based on schematic information, and low certainty predicts that projections will be based on sensory information.

This interpretation is supported by general psychology research on learning and memory from a range of contexts. For example, intolerance of uncertainty in autism is correlated with anxiety, which accounts for behavioural characteristics such as repetitive behaviour, and difficulties with change (Boulter, Freeston, South, & Rodgers, 2014; Rodgers, Hodgson, Shields et al., 2016). Additionally, Hohwy (2013) proposes that uncertainty in autism leads to a heavier reliance on sensory influences which can facilitate superior sensory processing, whereas typically developing individuals rely less on the sense, and more so on pre-existing schemas. It is also reported that despite a local precedence, implicit learning is intact in ASC for spatial, visual and motor processes (Barnes, Howard, & Howard et al., 2008; Brown et al., 2010; Izadi-Najafabadi et al., 2015; Foti, et al., 2015). Also, probabilistic sequence-learning and memory consolidation for visual stimuli is reported as being similar for autistic and TD children (Nemeth, Janacsek, and Balogh et al., 2010) which indicates that sequence-specific learning extends over long periods in autism. Implicit learning of spoken language is also reported in children and adults with ASC (Arnett, Hudac, & Deschamps et al., 2018; Tesink, Buitelaar, & Petersson et al. 2009), although it is proposed that some compensatory activation may be present. In terms of music, DePape, Hall, Tillmann and Trainor (2012) report that implicit learning of global harmonic structure, pitch memory and metrical processing is similar for ASC and controls. They also suggest that, given that harmonic processing is likely to rely on relative pitch, that individuals with ASC may switch between perceptual strategies depending on the task, where pitch memory can be processed using absolute pitch, and harmonic structure can be processed using relative pitch. The current study contributes to the consensus that implicit learning for global structure is active in autistic individuals, providing evidence for the assimilation of some structural musical properties depending on how the broad the implications are (e.g. whether they relate to deep-rooted knowledge of tonal structure rather than the patterning of a specific stimulus), and whether they are encoded schematically or veridically.

If implicit learning mechanisms are active in autism, then what is driving the perceptual differences observed in this population? It has been argued that individuals with ASC present difficulties in applying implicitly learned knowledge to real-world processes (Brown et al., 2010), that the relationship between semantic and episodic long-term memory may be atypical (Toichi & Kamio, 2002), and that a reduction in long-range neural connectivity may lead to difficulties with top-down processing (DePape et al., 2012). Significantly, several studies propose that individuals with autism experience an episodic memory deficit, but that their semantic memory system is preserved. This has been investigated using various paradigms, such as the Historical Figures Task (Gaigg, Bowler, & Gardiner, 2014) which investigates serial order memory, Remember/Know recognition procedures (Bowler, Gardiner, & Grice, 2000; Bowler, Gardiner, & Gaigg,

2007) which reveal that ASC participants report more instances of knowing rather than remembering, and difficulties with retrieval of autobiographical memories (Crane & Goddard, 2008). However, one criticism of these studies is that they investigate static memory and may not be representative of the long-term memory processes that are involved in dynamic music listening. On the other hand, the current study captures dynamic changes in perception and therefore contributes to research on music perception in autism. It has been suggested that semantic memory represents factual musical knowledge that is not connected to a personal experience, whereas episodic musical memory represents an ability to retrieve the personal and emotional context (Snyder, 2009; Mikutta, Strik, Knight, & Altorfer, 2015). Elsewhere it is reported that veridical expectations are derived from episodic memory, conceiving of the temporal structure or progression of a piece, whereas schematic expectations are based on semantic information that provides general information about patterning (Egermann, Pearce, & Wiggins et al., 2013). However, Huron points out that such a distinction is problematic, since listeners do not always remember the first time that they heard a familiar piece. It is thus proposed that subordinate veridical expectations in children with ASC may be due to an episodic memory deficit that generates an atypical interaction between working memory and long-term memory. This may also be due to a sensory processing precedence, where each event is presented in isolation from the next.

7.4.6 Limitations

Close attention to contour was observed during the rating task, which may have resulted from attention or comprehension difficulties, therefore these potential confounding elements are discussed here. The current study's paradigm requires that participants can understand the concept of expectation, or expectedness, and can explicitly make judgements based on that concept during a music listening and rating task. Although individuals with autism find it difficult to describe future events, and to project themselves into the future due to compromised episodic memory (Lind & Bowler, 2010; Schacter, Addis, & Buckner, 2008), it is suggested that this is limited to psychological tasks about the self (Wojcik, Moulin, & Souchay, 2013). Therefore, it is reasonable to suppose that individuals with autism can make predictions about what is coming next in a well-structured environment such as music. However, it is possible that difficulties with attention may have impacted ratings, as the ability to suppress interfering information or impulses is diminished in high-functioning autism (Daly et al., 2014; Xiao et al., 2012). Furthermore, although this study benefits from a combination of quantitative and descriptive analysis which identifies a range of response patterns, the use of descriptive analysis is more problematic when generalising the results, since there is much variation in the ratings and how they are interpreted. It would be beneficial for future research to aim to replicate these findings with a larger sample size with typically developing controls that are matched on IQ, so that the developmental trajectories of autistic listeners can be explored in more detail, and directly compared with those who are typically developing. Furthermore, the questionnaire data did not provide any significant results for ASC children, which could be due to the small sample size that ranged widely in age. It should be considered that autism is a spectrum condition with varying perceptual and cognitive characteristics, yet it is important to capture as much as possible about music perception since it is a vital communication tool in the absence (and even the presence) of speech, and can therefore enhance the lives of those with ASC in many contexts.

7.4.7 Children with ASC: summary

To summarise, this study demonstrates that during repeated listening to music, high-functioning autistic children perceive melody differently to typical children, identifying that a deficit in the episodic memory system may account for the way in which autistic children process melody. Specifically, ASC children are influenced more so by schematic expectations for hierarchical frameworks such as tonality (although not for grouping-based schemas), and less so by within-group and veridical expectations. Furthermore, a strong influence of melodic contour is exhibited in participants with ASC, which implies a bias towards local processing that accords with the EPF model of perception in autism that proposes enhanced sensory processing and intact global processing due to differences in brain organisation. Interestingly, the perceptual strategies employed by autistic listeners may depend on the strength of the melody's perceived implications. These results thus connect research on melody perception and memory in autism, proposing that subordinate veridical expectations and dominant schematic expectations result from an atypical episodic memory system, an intact semantic memory system, and the use of varying strategies in working memory that incorporates optional top-down processing and dominant bottom-up processing. Based on the present discussion, it is proposed that *certainty* is a significant factor which should be incorporated into future models of musical understanding in autism, since this directly influences perceptual strategies. For example, uncertainty would generate expectations based on sensory information, whereas certainty would generate expectations based on deep-rooted schemas.

7.5 Summary of findings

For clarity, the key findings from this chapter are summarised below, followed by some concluding observations in chapter 8.

- The expectations of adult listeners change systematically in response to repetition, where veridical expectations increase in dominance, whilst schematic and within-group expectations remain consistent, but are 'dampened' over time.
- Real-time music listening is analogous to an ever-moving temporal window, which means that schematic and within-group expectations always share a portion of the cognitive resources.

- Hence, listeners undergo two stages of listening as their familiarisation with a piece increases: a cumulative stage and a cyclic stage. The cumulative stage occurs between a first hearing and successive hearings, until the listener is familiar with a piece. The cyclic stage occurs as listeners rest and re-engage with familiar pieces.
- Future cognitive models could incorporate a *cumulative recency* and *cyclic recency* principle to mimic the rise and decay of memory that occurs as listeners rest and revisit pieces of music.
- As typically developing children grow older, the basis of their expectations progresses from single elements to connected elements, and from absolute to relative information, increasing in perceptual complexity.
- Accordingly, children aged 6-8 tend to be influenced mostly by schematic and within-group expectations for isolated pairs and groups of notes, whereas veridical expectations become influential at age 9-12 as connections between groups of notes are emerging.
- Perceiving relational properties become increasingly important as children develop, enabling them to retain relevant information and discard irrelevant information more efficiently. This is theorised to result from developmental changes in memory capacity and efficiency, and as a result of implicit learning via mere exposure.
- Autistic children show a local processing bias alongside a preserved ability to absorb global information for hierarchical frameworks such as tonality, but not for Gestalt-based grouping. Repetition does not appear to influence expectations.
- The findings also show that autistic children switch from top-down to bottom-up processing depending on the amount of predictive certainty in the music. If the melodic implications are ambiguous, then autistic children rely more on bottom-up processing, whereas if the music is highly predictable, they rely on top-down processing.

- It is theorised that the autistic auditory phenotype developed in this thesis is due to an atypical interaction between long-term memory and working-memory.
- It is also suggested that cognitive models of autistic music listeners could incorporate a principle of *certainty* that would highlight the distinction between processing strategies.

8 Conclusion

The aim of this thesis was to empirically investigate the role that melodic expectations play in the perception of melodic repetition as a result of 'typical' and 'atypical' development. Zygonic theory was selected as a framework for conceptualising, analysing and discussing the findings in this thesis. Chapters 3-5 each investigated a different group of participants, with the aim of generating a more comprehensive understanding of melodic perception and cognition.

Chapter 3 presents the results from experiment 1, which investigates the expectations of adult listeners. Analysis is framed by the first research question which focuses on whether melodic repetition influences the relationship between schematic, veridical and within-group expectations in 'typical' adult listeners. The results from experiment 1 show that adult listeners' long-term schematic expectations and Gestalt-based within-group expectations remain consistent, despite a cumulative increase in veridical expectations, which could contribute some explanation as to why listeners can savour anticipated moments of surprise in familiar pieces of music. It also appears that schematic and within-group expectations always share a portion of the cognitive resources even after multiple repetitions, which is thought to be analogous to an ever-moving temporal window (Bigand & Parncutt, 1999; Farbood, 2012) whereby listeners can only give their full attention to momentary sections of music, thereby always updating expectations. It is theorised that as listeners rest and re-engage with familiar pieces, memory decays and recovers indicating a dynamic cyclic shift in the interaction between schematic, within-group and veridical expectations.

Chapter 4 presents the results from experiment 2, which investigates typically developing children from three age groups from 6-8, 9-12, and 13-17. Analysis was focused on the second research question which is to understand the developmental norms that underpin melodic expectations. The results reveal that a developmental change occurs in each age group, where children base their expectations on absolute properties and pairs of notes at 6-8 years, on longer sequences of notes and connected groups at 9-12 years, as relational structures become more influential, and more complex relational structures at 13-17 years albeit with less consistency than adults. These findings represent changes in memory capacity and efficiency as children grow older.

The results from experiment 3 are presented in Chapter 5, which reveals that autistic children demonstrate a preference for local processing, but a deficit in local-level Gestalt processing; and an ability to process global schema-based structure, but not in a cumulative way that is sensitive to repetition. Autistic children may also switch processing strategies depending on the strength of melodic implications. It is theorised that the variance between autistic and typical children is due to an atypical interaction between long-term memory and working memory that contributes to differences in bottom-up and top-down processing and perceptual inflexibility.

Chapter 6 presents quantitative analysis of all three participant groups, focusing on the influence of repetition on perceived familiarity and how it differs between groups. The main findings taken from this chapter were that repetition becomes significantly more influential on perception as participants grow older, and that therefore in terms of modelling expectations using zygonic theory, the principle of recency becomes more influential with age, as memory becomes more efficient. ASC children are found to differ significantly from typical participants for an increasing number of trials as the age-gap widens. Interestingly, although autistic children exhibit the same response to repetition as 6-8-year-olds, autistic children show advanced global processing.

Chapter 7 presents a discussion for each participant group, drawing on studies from music psychology and memory development, and offers new theoretical grounds for understanding how pattern perception in music evolves. Additionally, developmental norms are highlighted, which can inform future research. Aesthetic responses to music in childhood and adulthood are also discussed in light of the results, as are contributions to the cognitive modelling of music.

8.1 Conceptual and methodological reflections

It is important to evaluate the findings in light of the study's strengths and limitations. Considering the outcomes summarised above, the main strengths of the study are the variation in participants in terms of age and developmental background as it reveals how melodic expectations develop according to two trajectories that have not previously been explored. This strength was enhanced by the decision to use the core concepts of zygonic theory as a conceptual framework for the study, which offered an empirical and theoretical basis upon which the analysis and discussion was structured, incorporating concepts derived from the work of Meyer, Bharucha, Narmour, and Huron. The combination of quantitative and descriptive analysis is also considered to be a strength because it means that subtle changes in perception based on description and informed interpretation can be supported by quantitative analysis.

Limitations were presented in chapter 7 that were appropriate for each participant group, most of which were considerations of the methods. Some final remarks on possible limitations are presented here. It is possible that the slow rate of stimulus presentation (40bpm) may have reduced the amount of information that participants can retain in memory as a result of short-term memory span, and although within-study consistency was preserved across participant groups, this could have impacted the rate at which memories are formed and thus also the projection of expectations, particularly in the youngest participants and those with autism, as they are less developed in terms of relative processing and may have benefitted from a quicker stimulus presentation rate.

Furthermore, it is not always possible to disentangle schematic, within-group and veridical expectations since they are part of a unified and typically non-conscious listening experience. Such separation is possible through descriptive analysis; however, it is acknowledged that this relies on the informed interpretations of the analyser. A further potential limitation of the study is that it utilises a single monophonic stimulus that includes only two phrases. Further, the number of stimulus repetitions was limited to eight, and the pause between listening sessions was limited to one week. Considering the study's objectives, the decision to use a monophonic stimulus was appropriate for observing specific changes in perception across participants who ranged widely in age and intellectual ability. Naturally, empirical investigation into music cognition and perception must adhere to constraints so that specific research questions can be examined. Progressive advances in knowledge can eventually generate new questions that can be addressed in the context of more ecologically valid stimuli, which may incorporate variation in harmony, tempo, rhythm, instrumentation, and structure.

8.2 Outcomes

The aim of this section is to present the findings from across all participant groups in the context of three key topics that are relevant to this study; namely aesthetic responses to music, the cognitive modelling of music, and music as a tool for education. This discussion will contribute to a more comprehensive understanding of melodic perception and cognition that can inform various avenues of research.

8.2.1 Aesthetic responses to music

In terms of exploring enduring aesthetic responses to familiar music, the findings contribute three aspects. The first contribution pertains to Berlyne's inverted-U of complexity and liking (Berlyne, 1971) which proposes that liking for a stimulus is correlated with its perceived complexity, where there exists a 'sweet spot' between simplicity and complexity. There is some debate about the relevance of Berlyne's work in the study of modern aesthetics, however it is recognised that the theory continues to find support in empirical research (Chmiel & Schubert, 2017). The current results also complement Berlyne's theory, in that repetition has a cumulative influence on familiarity that can rise and decay as a piece is rested and revisited, indicating that the critical point between simplicity and complexity can change, much like Berlyne's proposition that increased exposure to a stimulus can increase arousal, but that too much can cause aversion (Berlyne, 1969). Secondly, it is theorised from the present results that aesthetic responses to music might strengthen in intensity as children grow older, and may mature as children reach adolescence. Aesthetic responses are mediated by the surety of an individual's prediction and the strength of the prediction violation, thereby requiring that listeners understand embedded structure from which a predictable narrative can be projected. This accords with the finding that aesthetic judgment of an art form correlates with how well it is understood (Rodway, Kirkham, Schepman, Lambert, & Locke, 2016), and could also contribute to theories about why music is of particular importance to adolescents (Miranda, 2013; North, Hargreaves, & O'Neill, 2000). Arguably, aesthetic responses to music are most effective when the complexity of a piece of music matches an individual's capacity to understand the music, and although participants from each group are operating within a specific complexity level, there may be a baseline in terms of how complex a stimulus should be before it can generate an aesthetic or emotional response. This is perhaps an area for future research. The third contribution regards autistic listeners. It is theorised that due to their perceptual profile – where absolute information processing is prominent but not to the detriment of global processing, and there is little or no cumulative influence of repetition – they may undergo a single stage of listening, where perception is weighted by deeply embedded schemas and local elements, but discounts Gestalt-based processes, generating a sense that they are listening to the piece as though for the first time with more intensity than typical listeners; a different listening experience compared to the typical brain, but one that still generates intramusical emotional pleasure.

8.2.2 Modelling expectations

The findings in this thesis can be integrated to form a multidimensional model of melodic expectation that considers repeated listening to music in people of varying ages and different development profiles with reference to general memory research. As indicated in the literature review, there are multiple models of expectation, which tend to share the same core elements, that is; the conflict theory of emotions, Gestalt-based perception, and statistical learning. Zygonic theory was considered a suitable framework for the investigation of expectations in response to repeated listening as it provides the grounds for how specific and general implications may arise as music becomes more familiar. Zygonic model, Z3 introduces the principles of adjacency, recency, and within-groups, and successfully simulates listeners' predictions on a first hearing of a monophonic melody (Thorpe et al., 2012). Trower, Ockelford, and Bonneville-Roussy (forthcoming), demonstrate how an extended model, Z4, which additionally includes a within-groups principle that is representative of patterns occurring during current listening, could simulate listeners' expectations for repeated hearings of a melody. Further still, the findings from the current study suggest that the between-groups principle may interact with the principle of cumulative recency or cyclic recency, depending on how familiar one is with a piece of music. In which case, repeated listening would result in repeated between-groups becoming systematically more influential, and the cumulative or cyclic element would simulate the rate of memory decay. The strength of these principles would be altered depending on the age and developmental background of the listener. For example, as proposed in this study, younger children are less influenced by veridical expectations, and so the between-groups principle would not hold as much predictive weight as it would for adult listeners. The results from this study also indicate that a cognitive model of autistic listeners would incorporate a principle that represents a switch between bottom-up and top-down processing, which would hinge on the level of predictive certainty in the music. For example, a high level of certainty would generate schema-based predictions, whereas a low level of certainty would generate predictions based on absolute information. Zygonic modelling of autistic listeners would therefore modify the strength of each principle (adjacency, recency, between-groups and within-groups) according to the amount of predictive certainty in the music. For example, when certainty is low, the grouping-based principles might be less influential, which would reflect a local processing bias. When certainty is high, within-groups may be more influential, but the between-groups principle would continue to be subordinate in the same way that veridical expectations are in autistic listeners. These initial suggestions provide the groundwork for future models that can simulate the melodic cognition and perception of listeners at varying developmental stages, as well as incorporating the common experience of listening to familiar music.

8.2.3 Education

The findings and theories explored in this thesis also have implications for education for typically developing children and those with ASC. For example, the above discussion implies that children with autism perceive the world with a bias towards bottom-up processing, and they find it difficult to engage dynamically, particularly if there is lot of uncertainty in the environment. These findings therefore highlight the importance that music plays in maintaining order in an individual’s perceptual world, adding structure via repetition. Furthermore, these findings accord with models of perception in autism, indicating that beyond music, such as in educational and home contexts, autistic children find it easier to understand explicit language rather than abstract concepts, and this knowledge is vital for ensuring that those with autism can maximise their time in education, that confusion is reduced, and that they can better integrate with those around them. In terms of typically developing children, the present findings reveal how perception and cognition of pattern and structure develops, demonstrating various stages through which children progress. This can inform music-based educational applications by providing knowledge about whether children attend to absolute or relational properties, the amount of sequential information that they can attend to, and how they organise melodic structure. These findings may also support non-musical educational activities that involve auditory perception such as working with numbers and language.

8.3 Conclusion

In conclusion, this thesis offers new knowledge to the field of expectation in music, at a time when the study of expectation is increasingly recognised as fundamental for all of human experience and action. Music presents a self-contained structured environment that incorporates regularity and irregularity, that is therefore ideal for understanding how the brain makes dynamic predictions, and the processes that underpin those predictions. The current results also contribute knowledge to the broader fields of aesthetics, memory, learning, and prediction in people of varying ages and developmental trajectories which can be applied in a variety of contexts. Lastly, the findings presented in this thesis are valuable for future cognitive models of musical understanding through incorporating the pleasurable experience of listening to the same pieces of music throughout life.

Appendices

Appendix A: Normality tables for adult participants.

A Shapiro-Wilk test for each trial revealed that a proportion of the data were not normally distributed, as indicated by the significant values shown in Tables A1 and A2. Subsequently, the skewness and kurtosis distributions were examined. Following the recommendation that moderately normal data should fall between 0 and +/- 2.0 for skewness and between 0 and +/- 7.0 for kurtosis (Curran, West & Finch, 1996; Gravetter & Wallnau, 2014), Table A3 indicates that the data for five out of eight trials are within the normal distribution threshold for kurtosis, and all eight trials are within the normal distribution threshold for skewness. Non-normal figures outside of this threshold are highlighted in bold. It is also recommended that z-scores should fall within 0 and +/- 1.96 if the data are normal, and that scores outside of this threshold represent significant skewness or kurtosis. Again, non-normal data are highlighted in bold, and in this case, data for half of the trials are skewed. These results combined (Tables A1, A2 and A3) indicate that a proportion of the data pertaining to the adult participant group are not normally distributed. Data transformation is suggested in cases of non-normality where skewness direction is consistent across the dataset (Field, 2017). However, tests of normality that were performed on the data provided by typically developing children and autistic children reveals that the majority of data are normal, and in cases of skewness, the direction is mixed (see chapters 4 and 5 for results). As comparisons are made across the participant groups, and considering the above reported recommendations pertaining to skewness and kurtosis thresholds, the decision was made not to transform the data.

Table A1. Adult participants. Shapiro-Wilk test for normality split by session.

Session	Statistic	*p* value
Session 1	0.945	0.086
Session 2	0.9	0.005**

**p* < .05. ***p* < .01. ****p* < .001.

Table A2. Adults participants. Shapiro-Wilk test for normality split by trial.

Session	Trial	Statistic	*p* value
Session 1	Trial 1	0.983	0.865
	Trial 2	0.946	0.096
	Trial 3	0.91	0.009**
	Trial 4	0.801	0.000***
Session 2	Trial 5	0.96	0.236
	Trial 6	0.894	0.003**
	Trial 7	0.831	0.000***
	Trial 8	0.827	0.000***

**p* < .05. ***p* < .01. ****p* < .001.

Table A3. Adult participants. Skewness and kurtosis z-scores split by trial.

Session	Trial	Skewness	Std. Error of Skewness	Skewness z-score	Kurtosis	Std. Error of Kurtosis	Kurtosis z-score
Session 1	Trial 1	-0.11	0.361	-0.304	**-0.765**	0.709	-1.079
	Trial 2	-0.3	0.361	-0.831	**-0.864**	0.709	-1.219
	Trial 3	-0.749	0.361	**-2.075**	0.067	0.709	0.094
	Trial 4	-1.726	0.361	**-4.781**	**3.692**	0.709	**5.207**
Session 2	Trial 5	-0.52	0.403	-1.29	-0.397	0.788	-0.504
	Trial 6	-0.663	0.403	-1.645	-0.631	0.788	-0.801
	Trial 7	-1.159	0.403	**-2.876**	0.378	0.788	0.48
	Trial 8	-0.971	0.403	**-2.409**	-0.345	0.788	-0.438

Appendix B: Normality tests for typically developing children

A Shapiro-Wilk test for each session (Tables B1, B3, and B5) and for each trial (Tables B2, B4, and B6) grouped by age category, reveal that a proportion of the data are not normally distributed, as indicated by the significant *p* values. There is one significant instance of non-normal data for children aged 6-8, three instances of non-normal data for children aged 9-12, and four instances of non-normal data for children aged 13-17.

Table B1. TD children aged 6-8. Shapiro-Wilk test for normality split by session.

Session	Statistic	*p* value
Session 1	0.983	0.771
Session 2	0.965	0.203

**p* < .05. ***p* < .01. ****p* < .001.

Table B2. TD children aged 6-8. Shapiro-Wilk test for normality split by trial.

Session	Trial	Statistic	*p* value
Session 1	Trial 1	0.978	0.571
	Trial 2	0.977	0.508
	Trial 3	0.976	0.475
	Trial 4	0.976	0.485
Session 2	Trial 5	0.98	0.615
	Trial 6	0.962	0.152
	Trial 7	0.974	0.423
	Trial 8	0.944	0.034*

**p* < .05. ***p* < .01. ****p* < .001.

Table B3. TD children aged 9-12. Shapiro-Wilk test for normality split by session.

Session	Statistic	*p* value
Session 1	0.944	0.024*
Session 2	0.933	0.009**

*p < .05. **p < .01. ***p < .001.

Table B4. TD children aged 9-12. Shapiro-Wilk test for normality split by trial.

Session	Trial	Statistic	*p* value
Session 1	Trial 1	0.981	0.601
	Trial 2	0.969	0.23
	Trial 3	0.961	0.107
	Trial 4	0.961	0.108
Session 2	Trial 5	0.962	0.122
	Trial 6	0.92	0.003**
	Trial 7	0.904	0.001**
	Trial 8	0.886	0.000***

*p < .05. **p < .01. ***p < .001.

Table B5. TD children aged 13-17. Shapiro-Wilk test for normality split by session.

Session	Statistic	*p* value
Session 1	0.974	0.258
Session 2	0.948	0.014*

*p < .05. **p < .01. ***p < .001.

Table B6. TD children aged 13-17. Shapiro-Wilk test for normality split by trial.

Session	Trial	Statistic	*p* value
Session 1	Trial 1	0.982	0.532
	Trial 2	0.981	0.491
	Trial 3	0.965	0.089
	Trial 4	0.954	0.027*
Session 2	Trial 5	0.962	0.067
	Trial 6	0.947	0.013*

Trial 7	0.926	0.002**
Trial 8	0.896	0.000***

*p < .05. **p < .01. ***p < .001.

Tables B7, B8, and B9 indicate that the direction of skewness is not consistent across the participant groups as indicated by some positive and some negative numbers, therefore data transformation cannot solve the occasional non-normal distribution (Field, 2017). It is proposed that moderately normal data falls between 0 and +/- 2.0 for skewness and between 0 and +/- 7.0 for kurtosis (Curran, West, & Finch, 1996; Gravetter & Wallnau, 2014). All values for skewness and kurtosis in Tables B7, B8, and B9 are within the moderately normal range, which supports the decision to leave the data untransformed.

Table B7. TD children aged 6-8. Skewness and kurtosis z-scores split by trial.

Session	Trial	Skewness	Std. Error of Skewness	Skewness z-score	Kurtosis	Std. Error of Kurtosis	Kurtosis z-score
Session 1	Trial 1	0.345	0.357	0.964	-0.328	0.702	-0.467
	Trial 2	0.103	0.357	0.289	-0.621	0.702	-0.885
	Trial 3	0.047	0.357	0.131	-0.906	0.702	-1.292
	Trial 4	-0.176	0.357	-0.492	-0.692	0.702	-0.986
Session 2	Trial 5	0.070	0.357	0.196	-0.555	0.702	-0.791
	Trial 6	0.001	0.357	0.004	-1.097	0.702	-1.563
	Trial 7	-0.121	0.357	-0.339	-0.624	0.702	-0.889
	Trial 8	0.100	0.357	0.279	-1.179	0.702	-1.680

Table B8. TD children aged 9-12. Skewness and kurtosis z-scores split by trial.

Session	Trial	Skewness	Std. Error of Skewness	Skewness z-score	Kurtosis	Std. Error of Kurtosis	Kurtosis z-score
Session 1	Trial 1	0.166	0.340	0.489	-0.355	0.668	-0.531
	Trial 2	-0.005	0.340	-0.014	-0.972	0.668	-1.456
	Trial 3	-0.154	0.340	-0.452	-1.039	0.668	-1.556
	Trial 4	-0.242	0.340	-0.713	-0.864	0.668	-1.294
Session 2	Trial 5	-0.567	0.340	-1.667	-0.110	0.668	-0.165
	Trial 6	-0.900	0.340	**-2.650**	0.581	0.668	0.869
	Trial 7	-0.847	0.340	**-2.493**	0.019	0.668	0.028
	Trial 8	-1.103	0.340	**-3.245**	0.755	0.668	1.130

Table B9. TD children aged 13-17. Skewness and kurtosis z-scores split by trial.

Session	Trial	Skewness	Std. Error of Skewness	Skewness z-score	Kurtosis	Std. Error of Kurtosis	Kurtosis z-score
Session 1	Trial 1	-0.439	0.304	-1.444	0.627	0.599	1.046
	Trial 2	-0.304	0.304	-1.002	-0.170	0.599	-0.284
	Trial 3	-0.614	0.304	**-2.020**	0.112	0.599	0.186
	Trial 4	-0.606	0.304	**-1.994**	0.223	0.599	0.372
Session 2	Trial 5	0.034	0.314	0.107	-0.899	0.618	-1.455
	Trial 6	-0.628	0.314	**-2.001**	-0.254	0.618	-0.411
	Trial 7	-0.518	0.314	-1.650	-0.706	0.618	-1.143
	Trial 8	-1.054	0.314	**-3.360**	1.002	0.618	1.621

Appendix C: Normality tests for autistic children.

A Shapiro-Wilk test for each session (Table C1) and for each trial (Table C2), reveal that the majority of data are normally distributed, and only the final trial in each session are non-normal as indicated by the significant *p* values. Follow up observations of skewness and kurtoses are presented in Table C3. It is recommended that moderately normal data sits between 0 and +/- 2.0 for skewness and between 0 and +/- 7.0 for kurtosis, therefore the data can be regarded as normally distributed for the purposes of analysis.

Table C1. ASC children. Shapiro-Wilk test for normality split by session.

Session	Statistic	*p* value
Session 1	0.956	0.223
Session 2	0.943	0.098

*$p < .05$. **$p < .01$. ***$p < .001$.

Table C2. ASC children. Shapiro-Wilk test for normality split by trial.

Session	Trial	Statistic	*p* value
Session 1	Trial 1	0.967	0.482
	Trial 2	0.951	0.196
	Trial 3	0.953	0.225
	Trial 4	0.92	0.031*
Session 2	Trial 5	0.941	0.108
	Trial 6	0.953	0.213
	Trial 7	0.961	0.341
	Trial 8	0.919	0.028*

*$p < .05$. **$p < .01$. ***$p < .001$.

Table C3. ASC children. Skewness and kurtosis z-scores split by trial.

Session	Trial	Skewness	Std. Error of Skewness	Skewness z-score	Kurtosis	Std. Error of Kurtosis	Kurtosis z-score
Session 1	Trial 1	-0.384	0.414	-0.927536	-0.14	0.809	-0.17305
	Trial 2	0.073	0.414	0.1763285	-1.01	0.809	-1.24845
	Trial 3	0.293	0.414	0.7077295	-0.94	0.809	-1.16193
	Trial 4	0.017	0.414	0.0410628	-1.317	0.809	-1.62794
Session 2	Trial 5	-0.452	0.421	-1.073634	-0.812	0.821	-0.98904
	Trial 6	-0.369	0.421	-0.876485	-0.622	0.821	-0.75761
	Trial 7	-0.016	0.421	-0.038005	-0.961	0.821	-1.17052
	Trial 8	-0.163	0.434	-0.375576	-1.19	0.845	-1.40828

Appendix D: Between-group comparisons

Participant group		All trials whole melody					Trial 1 whole melody					Trial 2 whole melody				
		Mean diff.	SE	*p* value	95% confidence interval		Mean diff.	SE	*p* value	95% confidence interval		Mean diff.	SE	*p* value	95% confidence interval	
					lower bound	upper bound				lower bound	upper bound				lower bound	upper bound
6-8	9-12	-9.12	3.31	0.054	-18.33	0.09	0.09	3.702	1	-10.21	10.4	0.09	3.702	1	-10.21	10.4
	13-17	-10.92	3.078	0.005**	-19.48	-2.36	-1.06	3.56	0.998	-10.96	8.84	-1.06	3.56	0.998	-10.96	8.84
	18+	-17.8	3.379	0.000***	-27.25	-8.35	-9.21	3.663	0.097	-19.42	1	-9.21	3.663	0.097	-19.42	1
	ASC	4.6	5.295	0.906	-10.5	19.71	6.16	5.605	0.806	-9.72	22.04	6.16	5.605	0.806	-9.72	22.04
9-12	6-8	9.12	3.31	0.054	-0.09	18.33	-0.09	3.702	1	-10.4	10.21	-0.09	3.702	1	-10.4	10.21
	13-17	-1.8	3.132	0.978	-10.51	6.9	-1.15	3.493	0.997	-10.85	8.54	-1.15	3.493	0.997	-10.85	8.54
	18+	-8.68	3.429	0.094	-18.26	0.9	-9.3	3.598	0.082	-19.32	0.72	-9.3	3.598	0.082	-19.32	0.72
	ASC	13.73	5.327	0.093	-1.45	28.9	6.07	5.563	0.811	-9.7	21.83	6.07	5.563	0.811	-9.7	21.83
13-17	6-8	10.92	3.078	0.005**	2.36	19.48	1.06	3.56	0.998	-8.84	10.96	1.06	3.56	0.998	-8.84	10.96
	9-12	1.8	3.132	0.978	-6.9	10.51	1.15	3.493	0.997	-8.54	10.85	1.15	3.493	0.997	-8.54	10.85
	18+	-6.88	3.205	0.212	-15.84	2.09	-8.15	3.452	0.135	-17.75	1.45	-8.15	3.452	0.135	-17.75	1.45
	ASC	15.53	5.186	0.036*	0.69	30.36	7.22	5.469	0.681	-8.31	22.75	7.22	5.469	0.681	-8.31	22.75
18+	6-8	17.8	3.379	0.000***	8.35	27.25	9.21	3.663	0.097	-1	19.42	9.21	3.663	0.097	-1	19.42
	9-12	8.68	3.429	0.094	-0.9	18.26	9.3	3.598	0.082	-0.72	19.32	9.3	3.598	0.082	-0.72	19.32
	13-17	6.88	3.205	0.212	-2.09	15.84	8.15	3.452	0.135	-1.45	17.75	8.15	3.452	0.135	-1.45	17.75
	ASC	22.41	5.37	0.001**	7.11	37.7	15.37	5.537	0.058	-0.34	31.08	15.37	5.537	0.058	-0.34	31.08
ASC	6-8	-4.6	5.295	0.906	-19.71	10.5	-6.16	5.605	0.806	-22.04	9.72	-6.16	5.605	0.806	-22.04	9.72
	9-12	-13.73	5.327	0.093	-28.9	1.45	-6.07	5.563	0.811	-21.83	9.7	-6.07	5.563	0.811	-21.83	9.7
	13-17	-15.53	5.186	0.036*	-30.36	-0.69	-7.22	5.469	0.681	-22.75	8.31	-7.22	5.469	0.681	-22.75	8.31
	18+	-22.41	5.37	0.001**	-37.7	-7.11	-15.37	5.537	0.058	-31.08	0.34	-15.37	5.537	0.058	-31.08	0.34

*p < .05. **p < .01. ***p < .001.

Table D1. Whole melody. Games-Howell post-hoc multiple comparisons for all trials, trial 1, and trial 2.

Participant group		Trial 3 whole melody					Trial 4 whole melody					Trial 5 whole melody				
		Mean diff.	SE	*p* value	95% confidence interval		Mean diff.	SE	*p* value	95% confidence interval		Mean diff.	SE	*p* value	95% confidence interval	
					lower bound	upper bound				lower bound	upper bound				lower bound	upper bound
6-8	9-12	-9.42	3.842	0.111	-20.12	1.27	-7.34	4.158	0.4	-18.92	4.23	-9.66	4.175	0.151	-21.29	1.97
	13-17	-11.41	3.53	0.014	-21.23	-1.59	-11.36	3.796	0.029*	-21.93	-0.79	-10.45	3.886	0.064	-21.29	0.39
	18+	-19.32	3.601	0.000***	-29.36	-9.28	-19.75	4.281	0.000***	-31.68	-7.82	-16.32	4.174	0.002**	-27.99	-4.66
	ASC	8	5.298	0.56	-6.96	22.97	4.86	5.891	0.922	-11.79	21.51	0.51	5.752	1	-15.72	16.73
9-12	6-8	9.42	3.842	0.111	-1.27	20.12	7.34	4.158	0.4	-4.23	18.92	9.66	4.175	0.151	-1.97	21.29
	13-17	-1.99	3.528	0.98	-11.79	7.82	-4.02	3.721	0.817	-14.36	6.32	-0.79	3.504	0.999	-10.53	8.95
	18+	-9.9	3.6	0.055	-19.92	0.12	-12.41	4.215	0.033*	-24.15	-0.67	-6.66	3.821	0.413	-17.33	4.01
	ASC	17.43	5.297	0.015*	2.47	32.39	12.2	5.843	0.241	-4.32	28.73	10.17	5.501	0.359	-5.41	25.74
13-17	6-8	11.41	3.53	0.014*	1.59	21.23	11.36	3.796	0.029*	0.79	21.93	10.45	3.886	0.064	-0.39	21.29
	9-12	1.99	3.528	0.98	-7.82	11.79	4.02	3.721	0.817	-6.32	14.36	0.79	3.504	0.999	-8.95	10.53
	18+	-7.91	3.264	0.118	-16.98	1.16	-8.39	3.858	0.199	-19.14	2.36	-5.87	3.503	0.455	-15.67	3.92
	ASC	19.41	5.074	0.003**	5.01	33.81	16.22	5.591	0.043*	0.33	32.11	10.96	5.285	0.25	-4.08	26
18+	6-8	19.32	3.601	0.000***	9.28	29.36	19.75	4.281	0.000***	7.82	31.68	16.32	4.174	0.002**	4.66	27.99
	9-12	9.9	3.6	0.055	-0.12	19.92	12.41	4.215	0.033	0.67	24.15	6.66	3.821	0.413	-4.01	17.33
	13-17	7.91	3.264	0.118	-1.16	16.98	8.39	3.858	0.199	-2.36	19.14	5.87	3.503	0.455	-3.92	15.67
	ASC	27.32	5.124	0.000***	12.79	41.85	24.61	5.931	0.001**	7.86	41.37	16.83	5.5	0.028	1.24	32.42
ASC	6-8	-8	5.298	0.56	-22.97	6.96	-4.86	5.891	0.922	-21.51	11.79	-0.51	5.752	1	-16.73	15.72
	9-12	-17.43	5.297	0.015*	-32.39	-2.47	-12.2	5.843	0.241	-28.73	4.32	-10.17	5.501	0.359	-25.74	5.41
	13-17	-19.41	5.074	0.003**	-33.81	-5.01	-16.22	5.591	0.043*	-32.11	-0.33	-10.96	5.285	0.25	-26	4.08
	18+	-27.32	5.124	0	-41.85	-12.79	-24.61	5.931	0.001**	-41.37	-7.86	-16.83	5.5	0.028**	-32.42	-1.24

*p < .05. **p < .01. ***p < .001.

Table D2. Whole melody. Games-Howell post-hoc multiple comparisons for trials 3, 4, and 5.

Participant group		Trial 6 whole melody					Trial 7 whole melody					Trial 8 whole melody				
		Mean diff.	SE	*p* value	95% confidence interval		Mean diff.	SE	*p* value	95% confidence interval		Mean diff.	SE	*p* value	95% confidence interval	
					lower bound	upper bound				lower bound	upper bound				lower bound	upper bound
6-8	9-12	-11.54	4.264	0.061	-23.41	0.34	-12.89	4.239	0.025*	-24.69	-1.09	-14.64	4.519	0.014*	-27.24	-2.05
	13-17	-13.32	3.838	0.007*	-24.02	-2.61	-14.54	3.91	0.003**	-25.44	-3.64	-17.62	4.197	0.001**	-29.34	-5.9
	18+	-18.63	4.282	0.000***	-30.6	-6.66	-20.39	4.331	0.000***	-32.49	-8.29	-22.94	4.361	0.000***	-35.13	-10.74
	ASC	3.3	6.074	0.982	-13.88	20.48	5.96	6.007	0.858	-11.02	22.95	4.51	6.832	0.964	-14.87	23.88
9-12	6-8	11.54	4.264	0.061	-0.34	23.41	12.89	4.239	0.025*	1.09	24.69	14.64	4.519	0.014*	2.05	27.24
	13-17	-1.78	3.66	0.988	-11.96	8.4	-1.65	3.746	0.992	-12.06	8.76	-2.98	3.705	0.929	-13.28	7.32
	18+	-7.09	4.123	0.428	-18.61	4.42	-7.5	4.183	0.385	-19.19	4.19	-8.29	3.89	0.217	-19.15	2.56
	ASC	14.84	5.964	0.11	-2.06	31.73	18.85	5.901	0.02*	2.14	35.56	19.15	6.542	0.042*	0.5	37.8
13-17	6-8	13.32	3.838	0.007*	2.61	24.02	14.54	3.91	0.003**	3.64	25.44	17.62	4.197	0.001**	5.9	29.34
	9-12	1.78	3.66	0.988	-8.4	11.96	1.65	3.746	0.992	-8.76	12.06	2.98	3.705	0.929	-7.32	13.28
	18+	-5.31	3.681	0.603	-15.62	5	-5.85	3.85	0.553	-16.63	4.93	-5.32	3.51	0.556	-15.12	4.49
	ASC	16.62	5.667	0.041	0.46	32.78	20.5	5.67	0.007**	4.36	36.64	22.13	6.324	0.01*	4	40.25
18+	6-8	18.63	4.282	0.000***	6.66	30.6	20.39	4.331	0.000***	8.29	32.49	22.94	4.361	0.000***	10.74	35.13
	9-12	7.09	4.123	0.428	-4.42	18.61	7.5	4.183	0.385	-4.19	19.19	8.29	3.89	0.217	-2.56	19.15
	13-17	5.31	3.681	0.603	-5	15.62	5.85	3.85	0.553	-4.93	16.63	5.32	3.51	0.556	-4.49	15.12
	ASC	21.93	5.977	0.005**	4.99	38.87	26.35	5.968	0.001**	9.45	43.25	27.44	6.433	0.001**	9.05	45.84
ASC	6-8	-3.3	6.074	0.982	-20.48	13.88	-5.96	6.007	0.858	-22.95	11.02	-4.51	6.832	0.964	-23.88	14.87
	9-12	-14.84	5.964	0.11	-31.73	2.06	-18.85	5.901	0.02*	-35.56	-2.14	-19.15	6.542	0.042	-37.8	-0.5
	13-17	-16.62	5.667	0.041	-32.78	-0.46	-20.5	5.67	0.007**	-36.64	-4.36	-22.13	6.324	0.01*	-40.25	-4
	18+	-21.93	5.977	0.005**	-38.87	-4.99	-26.35	5.968	0.001**	-43.25	-9.45	-27.44	6.433	0.001**	-45.84	-9.05

*p < .05. **p < .01. ***p < .001.

Table D3. Whole melody. Games-Howell post-hoc multiple comparisons for trials 6, 7, and 8.

Participant group		All trials phrase A					Trial 1 phrase A					Trial 2 phrase A				
		Mean diff.	SE	*p* value	95% confidence interval		Mean diff.	SE	*p* value	95% confidence interval		Mean diff.	SE	*p* value	95% confidence interval	
					lower bound	upper bound				lower bound	upper bound				lower bound	upper bound
6-8	9-12	-9.87	3.52	0.047*	-19.67	-0.07	-2.36	4.03	0.98	-13.57	8.84	-6.96	4.29	0.49	-18.93	5.00
	13-17	-11.52	3.29	0.006**	-20.68	-2.36	-1.65	3.83	0.99	-12.29	9.00	-9.52	4.04	0.14	-20.81	1.76
	18+	-19.70	3.52	0.000***	-29.54	-9.86	-14.18	3.85	0.004**	-24.91	-3.44	-20.60	4.10	0.000***	-32.05	-9.15
	ASC	7.78	5.56	0.63	-8.08	23.64	6.22	5.91	0.83	-10.49	22.94	7.60	5.70	0.67	-8.43	23.64
9-12	6-8	9.87	3.52	0.047*	0.07	19.67	2.36	4.03	0.98	-8.84	13.57	6.96	4.29	0.49	-5.00	18.93
	13-17	-1.65	3.18	0.99	-10.47	7.18	0.72	3.70	1.00	-9.57	11.01	-2.56	3.56	0.95	-12.46	7.34
	18+	-9.83	3.41	0.04*	-19.36	-0.29	-11.81	3.73	0.018*	-22.19	-1.43	-13.64	3.63	0.003**	-23.73	-3.54
	ASC	17.65	5.50	0.021*	1.95	33.35	8.59	5.83	0.59	-7.93	25.10	14.57	5.37	0.07	-0.60	29.74
13-17	6-8	11.52	3.29	0.006*	2.36	20.68	1.65	3.83	0.99	-9.00	12.29	9.52	4.04	0.14	-1.76	20.81
	9-12	1.65	3.18	0.99	-7.18	10.47	-0.72	3.70	1.00	-11.01	9.57	2.56	3.56	0.95	-7.34	12.46
	18+	-8.18	3.18	0.09	-17.06	0.70	-12.53	3.51	0.005**	-22.30	-2.76	-11.08	3.33	0.011*	-20.32	-1.83
	ASC	19.30	5.35	0.008*	3.95	34.64	7.87	5.70	0.64	-8.31	24.04	17.13	5.17	0.015*	2.46	31.80
18+	6-8	19.70	3.52	0.000***	9.86	29.54	14.18	3.85	0.004**	3.44	24.91	20.60	4.10	0.000***	9.15	32.05
	9-12	9.83	3.41	0.04*	0.29	19.36	11.81	3.73	0.02	1.43	22.19	13.64	3.63	0.00	3.54	23.73
	13-17	8.18	3.18	0.09	-0.70	17.06	12.53	3.51	0.005**	2.76	22.30	11.08	3.33	0.01	1.83	20.32
	ASC	27.48	5.50	0.000***	11.77	43.18	20.40	5.71	0.007**	4.18	36.62	28.20	5.22	0.000***	13.41	42.99
ASC	6-8	-7.78	5.56	0.63	-23.64	8.08	-6.22	5.91	0.83	-22.94	10.49	-7.60	5.70	0.67	-23.64	8.43
	9-12	-17.65	5.50	0.021*	-33.35	-1.95	-8.59	5.83	0.59	-25.10	7.93	-14.57	5.37	0.07	-29.74	0.60
	13-17	-19.30	5.35	0.008*	-34.64	-3.95	-7.87	5.70	0.64	-24.04	8.31	-17.13	5.17	0.015*	-31.80	-2.46
	18+	-27.48	5.50	0.000***	-43.18	-11.77	-20.40	5.71	0.007**	-36.62	-4.18	-28.20	5.22	0.000***	-42.99	-13.41

*p < .05. **p < .01. ***p < .001.

Table D4. Phrase A. Games-Howell post-hoc multiple comparisons for all trials, trial 1, and trial 2.

Participant group		Trial 3 phrase A					Trial 4 phrase A					Trial 5 phrase A				
		Mean diff.	SE	*p* value	95% confidence interval		Mean diff.	SE	*p* value	95% confidence interval		Mean diff.	SE	*p* value	95% confidence interval	
					lower bound	upper bound				lower bound	upper bound				lower bound	upper bound
6-8	9-12	-11.89	4.15	0.04*	-23.43	-0.35	-7.00	4.45	0.52	-19.38	5.39	-10.94	4.31	0.09	-22.94	1.06
	13-17	-13.63	3.78	0.005**	-24.15	-3.11	-11.33	4.05	0.049*	-22.64	-0.02	-12.26	3.93	0.02*	-23.21	-1.30
	18+	-22.54	3.84	0.000***	-33.26	-11.81	-20.40	4.30	0.000***	-32.41	-8.40	-19.06	4.20	0.000***	-30.81	-7.31
	ASC	9.29	5.48	0.45	-6.16	24.74	10.25	6.38	0.50	-7.78	28.28	3.90	5.87	0.96	-12.65	20.44
9-12	6-8	11.89	4.15	0.04*	0.35	23.43	7.00	4.45	0.52	-5.39	19.38	10.94	4.31	0.09	-1.06	22.94
	13-17	-1.74	3.60	0.99	-11.75	8.27	-4.33	3.77	0.78	-14.81	6.15	-1.32	3.64	1.00	-11.44	8.80
	18+	-10.64	3.67	0.037*	-20.87	-0.42	-13.41	4.04	0.011*	-24.65	-2.16	-8.12	3.94	0.25	-19.11	2.87
	ASC	21.18	5.37	0.002**	6.04	36.32	17.25	6.21	0.06	-0.33	34.83	14.83	5.68	0.08	-1.23	30.90
13-17	6-8	13.63	3.78	0.005**	3.11	24.15	11.33	4.05	0.049*	0.02	22.64	12.26	3.93	0.02*	1.30	23.21
	9-12	1.74	3.60	0.99	-8.27	11.75	4.33	3.77	0.78	-6.15	14.81	1.32	3.64	1.00	-8.80	11.44
	18+	-8.91	3.25	0.06	-17.93	0.12	-9.08	3.60	0.10	-19.10	0.95	-6.80	3.51	0.31	-16.63	3.02
	ASC	22.92	5.08	0.000***	8.49	37.35	21.58	5.93	0.006**	4.68	38.48	16.15	5.39	0.04	0.80	31.50
18+	6-8	22.54	3.84	0.000***	11.81	33.26	20.40	4.30	0.000***	8.40	32.41	19.06	4.20	0.000***	7.31	30.81
	9-12	10.64	3.67	0.037*	0.42	20.87	13.41	4.04	0.011*	2.16	24.65	8.12	3.94	0.25	-2.87	19.11
	13-17	8.91	3.25	0.06	-0.12	17.93	9.08	3.60	0.10	-0.95	19.10	6.80	3.51	0.31	-3.02	16.63
	ASC	31.82	5.13	0.000***	17.26	46.38	30.66	6.11	0.000***	13.32	47.99	22.96	5.60	0.001**	7.08	38.83
ASC	6-8	-9.29	5.48	0.45	-24.74	6.16	-10.25	6.38	0.50	-28.28	7.78	-3.90	5.87	0.96	-20.44	12.65
	9-12	-21.18	5.37	0.002**	-36.32	-6.04	-17.25	6.21	0.06	-34.83	0.33	-14.83	5.68	0.08	-30.90	1.23
	13-17	-22.92	5.08	0.000***	-37.35	-8.49	-21.58	5.93	0.006**	-38.48	-4.68	-16.15	5.39	0.04	-31.50	-0.80
	18+	-31.82	5.13	0.000***	-46.38	-17.26	-30.66	6.11	0.000***	-47.99	-13.32	-22.96	5.60	0.001**	-38.83	-7.08

$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table D5. Phrase A. Games-Howell post-hoc multiple comparisons for trials 3, 4, and 5.

Participant group		Trial 6 phrase A multiple comparisons					Trial 7 phrase A multiple comparisons					Trial 8 phrase A multiple comparisons				
		Mean diff.	SE	*p* value	95% confidence interval		Mean diff.	SE	*p* value	95% confidence interval		Mean diff.	SE	*p* value	95% confidence interval	
					lower bound	upper bound				lower bound	upper bound				lower bound	upper bound
6-8	9-12	-12.38	4.50	0.05	-24.90	0.15	-12.63	4.54	0.05	-25.30	0.03	-13.78	4.68	0.033*	-26.84	-0.72
	13-17	-13.35	4.02	0.011*	-24.57	-2.14	-13.92	4.18	0.011*	-25.61	-2.23	-15.91	4.37	0.004**	-28.11	-3.71
	18+	-20.22	4.15	0.000***	-31.81	-8.63	-20.36	4.45	0.000***	-32.81	-7.91	-21.97	4.40	0.000***	-34.27	-9.66
	ASC	5.07	6.43	0.93	-13.13	23.26	10.08	6.66	0.56	-8.78	28.93	8.70	7.36	0.76	-12.20	29.59
9-12	6-8	12.38	4.50	0.05	-0.15	24.90	12.63	4.54	0.05	-0.03	25.30	13.78	4.68	0.03	0.72	26.84
	13-17	-0.97	3.85	1.00	-11.69	9.74	-1.29	3.69	1.00	-11.54	8.96	-2.13	3.75	0.98	-12.55	8.29
	18+	-7.84	3.98	0.29	-18.96	3.27	-7.72	3.99	0.31	-18.86	3.41	-8.19	3.78	0.20	-18.74	2.37
	ASC	17.44	6.33	0.06	-0.49	35.37	22.71	6.36	0.007**	4.62	40.81	22.48	7.01	0.021*	2.44	42.51
13-17	6-8	13.35	4.02	0.011*	2.14	24.57	13.92	4.18	0.011*	2.23	25.61	15.91	4.37	0.004**	3.71	28.11
	9-12	0.97	3.85	1.00	-9.74	11.69	1.29	3.69	1.00	-8.96	11.54	2.13	3.75	0.98	-8.29	12.55
	18+	-6.87	3.43	0.28	-16.45	2.72	-6.43	3.57	0.38	-16.43	3.56	-6.06	3.38	0.39	-15.49	3.37
	ASC	18.42	6.00	0.029*	1.30	35.53	24.00	6.11	0.003**	6.52	41.48	24.61	6.81	0.008**	5.07	44.15
18+	6-8	20.22	4.15	0.000***	8.63	31.81	20.36	4.45	0.000***	7.91	32.81	21.97	4.40	.0000***	9.66	34.27
	9-12	7.84	3.98	0.29	-3.27	18.96	7.72	3.99	0.31	-3.41	18.86	8.19	3.78	0.20	-2.37	18.74
	13-17	6.87	3.43	0.28	-2.72	16.45	6.43	3.57	0.38	-3.56	16.43	6.06	3.38	0.39	-3.37	15.49
	ASC	25.29	6.08	0.001**	7.95	42.62	30.44	6.30	0.000***	12.49	48.38	30.67	6.82	0.001**	11.07	50.26
ASC	6-8	-5.07	6.43	0.93	-23.26	13.13	-10.08	6.66	0.56	-28.93	8.78	-8.70	7.36	0.76	-29.59	12.20
	9-12	-17.44	6.33	0.06	-35.37	0.49	-22.71	6.36	0.007**	-40.81	-4.62	-22.48	7.01	0.021*	-42.51	-2.44
	13-17	-18.42	6.00	0.029*	-35.53	-1.30	-24.00	6.11	0.003**	-41.48	-6.52	-24.61	6.81	0.008**	-44.15	-5.07
	18+	-25.29	6.08	0.001**	-42.62	-7.95	-30.44	6.30	0.000***	-48.38	-12.49	-30.67	6.82	0.001**	-50.26	-11.07

*p < .05. **p < .01. ***p < .001.

Table D6. Phrase A. Games-Howell post-hoc multiple comparisons for trials 6, 7, and 8.

Participant group		All trials phrase B					Trial 1 phrase B					Trial 2 phrase B				
		Mean diff.	SE	*p* value	95% confidence interval		Mean diff.	SE	*p* value	95% confidence interval		Mean diff.	SE	*p* value	95% confidence interval	
					lower bound	upper bound				lower bound	upper bound				lower bound	upper bound
6-8	9-12	-7.86	3.72	0.22	-18.20	2.49	3.80	4.40	0.91	-8.44	16.04	-7.68	4.66	0.47	-20.48	5.12
	13-17	-9.75	3.35	0.035*	-19.06	-0.44	0.06	4.07	1.00	-11.25	11.37	-4.27	4.42	0.87	-16.43	7.88
	18+	-14.68	3.96	0.004**	-25.76	-3.59	-1.59	4.76	1.00	-14.86	11.68	-9.57	4.81	0.27	-22.79	3.65
	ASC	1.51	5.79	1.00	-15.08	18.09	4.28	6.23	0.96	-13.36	21.92	5.11	5.26	0.87	-9.35	19.56
9-12	6-8	7.86	3.72	0.22	-2.49	18.20	-3.80	4.40	0.91	-16.04	8.44	7.68	4.66	0.47	-5.12	20.48
	13-17	-1.89	3.53	0.98	-11.70	7.92	-3.74	4.02	0.89	-14.92	7.44	3.41	4.28	0.93	-8.38	15.19
	18+	-6.82	4.11	0.47	-18.31	4.67	-5.39	4.72	0.78	-18.55	7.77	-1.89	4.68	0.99	-14.77	10.99
	ASC	9.36	5.90	0.51	-7.48	26.20	0.48	6.21	1.00	-17.09	18.04	12.79	5.14	0.10	-1.36	26.94
13-17	6-8	9.75	3.35	0.035*	0.44	19.06	-0.06	4.07	1.00	-11.37	11.25	4.27	4.42	0.87	-7.88	16.43
	9-12	1.89	3.53	0.98	-7.92	11.70	3.74	4.02	0.89	-7.44	14.92	-3.41	4.28	0.93	-15.19	8.38
	18+	-4.93	3.78	0.69	-15.53	5.67	-1.65	4.41	1.00	-13.97	10.66	-5.30	4.45	0.76	-17.53	6.94
	ASC	11.25	5.67	0.30	-5.04	27.55	4.22	5.97	0.95	-12.77	21.20	9.38	4.93	0.32	-4.18	22.94
18+	6-8	14.68	3.96	0.004**	3.59	25.76	1.59	4.76	1.00	-11.68	14.86	9.57	4.81	0.27	-3.65	22.79
	9-12	6.82	4.11	0.47	-4.67	18.31	5.39	4.72	0.78	-7.77	18.55	1.89	4.68	0.99	-10.99	14.77
	13-17	4.93	3.78	0.69	-5.67	15.53	1.65	4.41	1.00	-10.66	13.97	5.30	4.45	0.76	-6.94	17.53
	ASC	16.18	6.05	0.08	-1.05	33.42	5.87	6.47	0.89	-12.37	24.11	14.68	5.28	0.05	0.15	29.20
ASC	6-8	-1.51	5.79	1.00	-18.09	15.08	-4.28	6.23	0.96	-21.92	13.36	-5.11	5.26	0.87	-19.56	9.35
	9-12	-9.36	5.90	0.51	-26.20	7.48	-0.48	6.21	1.00	-18.04	17.09	-12.79	5.14	0.10	-26.94	1.36
	13-17	-11.25	5.67	0.30	-27.55	5.04	-4.22	5.97	0.95	-21.20	12.77	-9.38	4.93	0.32	-22.94	4.18
	18+	-16.18	6.05	0.08	-33.42	1.05	-5.87	6.47	0.89	-24.11	12.37	-14.68	5.28	0.05	-29.20	-0.15

*p < .05. **p < .01. ***p < .001.

Table D7. Phrase B. Games-Howell post-hoc multiple comparisons for all trials, trial 1, and Tukey HSD post-hoc test for trial 2.

Participant group		Trial 3 phrase B					Trial 4 phrase B					Trial 5 phrase B				
		Mean diff.	SE	*p* value	95% confidence interval		Mean diff.	SE	*p* value	95% confidence interval		Mean diff.	SE	*p* value	95% confidence interval	
					lower bound	upper bound				lower bound	upper bound				lower bound	upper bound
6-8	9-12	-6.28	4.78	0.68	-19.42	6.86	-7.10	5.12	0.64	-21.17	6.97	-7.61	5.11	0.57	-21.84	6.62
	13-17	-8.46	4.54	0.34	-20.94	4.02	-10.64	4.86	0.19	-24.00	2.71	-7.75	4.69	0.47	-20.84	5.35
	18+	-14.81	4.93	0.025*	-28.37	-1.25	-17.92	5.28	0.007**	-32.44	-3.39	-12.24	5.01	0.11	-26.23	1.75
	ASC	4.85	5.34	0.89	-9.83	19.53	-2.19	5.72	1.00	-17.93	13.55	-4.71	6.91	0.96	-24.20	14.78
9-12	6-8	6.28	4.78	0.68	-6.86	19.42	7.10	5.12	0.64	-6.97	21.17	7.61	5.11	0.57	-6.62	21.84
	13-17	-2.18	4.37	0.99	-14.20	9.84	-3.54	4.71	0.94	-16.49	9.41	-0.14	4.39	1.00	-12.35	12.07
	18+	-8.52	4.78	0.39	-21.66	4.62	-10.81	5.15	0.22	-24.97	3.34	-4.63	4.72	0.86	-17.81	8.55
	ASC	11.13	5.20	0.21	-3.16	25.42	4.92	5.60	0.91	-10.48	20.31	2.90	6.71	0.99	-16.06	21.86
13-17	6-8	8.46	4.54	0.34	-4.02	20.94	10.64	4.86	0.19	-2.71	24.00	7.75	4.69	0.47	-5.35	20.84
	9-12	2.18	4.37	0.99	-9.84	14.20	3.54	4.71	0.94	-9.41	16.49	0.14	4.39	1.00	-12.07	12.35
	18+	-6.34	4.54	0.63	-18.82	6.13	-7.27	4.89	0.57	-20.72	6.17	-4.49	4.27	0.83	-16.43	7.45
	ASC	13.31	4.98	0.06	-0.38	26.99	8.46	5.36	0.51	-6.29	23.20	3.04	6.40	0.99	-15.15	21.23
18+	6-8	14.81	4.93	0.025*	1.25	28.37	17.92	5.28	0.007**	3.39	32.44	12.24	5.01	0.11	-1.75	26.23
	9-12	8.52	4.78	0.39	-4.62	21.66	10.81	5.15	0.22	-3.34	24.97	4.63	4.72	0.86	-8.55	17.81
	13-17	6.34	4.54	0.63	-6.13	18.82	7.27	4.89	0.57	-6.17	20.72	4.49	4.27	0.83	-7.45	16.43
	ASC	19.65	5.34	0.003**	4.97	34.33	15.73	5.75	0.05	-0.09	31.55	7.53	6.63	0.79	-11.25	26.32
ASC	6-8	-4.85	5.34	0.89	-19.53	9.83	2.19	5.72	1.00	-13.55	17.93	4.71	6.91	0.96	-14.78	24.20
	9-12	-11.13	5.20	0.21	-25.42	3.16	-4.92	5.60	0.91	-20.31	10.48	-2.90	6.71	0.99	-21.86	16.06
	13-17	-13.31	4.98	0.06	-26.99	0.38	-8.46	5.36	0.51	-23.20	6.29	-3.04	6.40	0.99	-21.23	15.15
	18+	-19.65	5.34	0.003**	-34.33	-4.97	-15.73	5.75	0.05	-31.55	0.09	-7.53	6.63	0.79	-26.32	11.25

*p < .05. **p < .01. ***p < .001.

Table D8. Phrase B. Tukey post-hoc multiple comparisons for trials 3 and 4, and Games-Howell post-hoc test for trial 5.

Participant group		Trial 6 phrase B					Trial 7 phrase B					Trial 8 phrase B				
		Mean diff.	SE	*p* value	95% confidence interval		Mean diff.	SE	*p* value	95% confidence interval		Mean diff.	SE	*p* value	95% confidence interval	
					lower bound	upper bound				lower bound	upper bound				lower bound	upper bound
6-8	9-12	-10.82	4.88	0.18	-24.40	2.75	-12.59	5.28	0.12	-27.13	1.94	-16.13	5.24	0.023*	-30.73	-1.53
	13-17	-13.18	4.28	0.023*	-25.13	-1.23	-15.07	5.09	0.028*	-29.06	-1.08	-20.14	4.74	0.001**	-33.39	-6.90
	18+	-16.33	5.22	0.021*	-30.93	-1.73	-19.90	5.81	0.007**	-35.88	-3.92	-24.25	5.21	0.000***	-38.81	-9.70
	ASC	0.98	6.73	1.00	-18.02	19.98	0.05	5.96	1.00	-16.36	16.46	-1.62	7.13	1.00	-21.77	18.53
9-12	6-8	10.82	4.88	0.18	-2.75	24.40	12.59	5.28	0.12	-1.94	27.13	16.13	5.24	0.023*	1.53	30.73
	13-17	-2.35	4.06	0.98	-13.66	8.95	-2.48	4.94	0.99	-16.06	11.10	-4.01	4.24	0.88	-15.81	7.78
	18+	-5.50	5.04	0.81	-19.61	8.60	-7.31	5.68	0.70	-22.93	8.31	-8.12	4.76	0.44	-21.41	5.16
	ASC	11.80	6.59	0.39	-6.85	30.45	12.64	5.84	0.20	-3.42	28.70	14.51	6.81	0.23	-4.81	33.84
13-17	6-8	13.18	4.28	0.023*	1.23	25.13	15.07	5.09	0.028*	1.08	29.06	20.14	4.74	0.001**	6.90	33.39
	9-12	2.35	4.06	0.98	-8.95	13.66	2.48	4.94	0.99	-11.10	16.06	4.01	4.24	0.88	-7.78	15.81
	18+	-3.15	4.47	0.96	-15.73	9.43	-4.83	5.49	0.90	-19.95	10.28	-4.11	4.20	0.86	-15.88	7.66
	ASC	14.15	6.16	0.17	-3.44	31.75	15.12	5.66	0.06	-0.45	30.69	18.53	6.43	0.048*	0.12	36.93
18+	6-8	16.33	5.22	0.021*	1.73	30.93	19.90	5.81	0.007**	3.92	35.88	24.25	5.21	0.000***	9.70	38.81
	9-12	5.50	5.04	0.81	-8.60	19.61	7.31	5.68	0.70	-8.31	22.93	8.12	4.76	0.44	-5.16	21.41
	13-17	3.15	4.47	0.96	-9.43	15.73	4.83	5.49	0.90	-10.28	19.95	4.11	4.20	0.86	-7.66	15.88
	ASC	17.30	6.85	0.10	-2.04	36.65	19.95	6.32	0.02	2.57	37.33	22.64	6.79	0.014*	3.35	41.93
ASC	6-8	-0.98	6.73	1.00	-19.98	18.02	-0.05	5.96	1.00	-16.46	16.36	1.62	7.13	1.00	-18.53	21.77
	9-12	-11.80	6.59	0.39	-30.45	6.85	-12.64	5.84	0.20	-28.70	3.42	-14.51	6.81	0.23	-33.84	4.81
	13-17	-14.15	6.16	0.17	-31.75	3.44	-15.12	5.66	0.06	-30.69	0.45	-18.53	6.43	0.048*	-36.93	-0.12
	18+	-17.30	6.85	0.10	-36.65	2.04	-19.95	6.32	0.015*	-37.33	-2.57	-22.64	6.79	0.014*	-41.93	-3.35

*p < .05. **p < .01. ***p < .001.

Table D9. Phrase B. Games-Howell post-hoc multiple comparisons for trials 6 and 8, and Tukey post-hoc test for trial 7.

Appendix E: Participant consent form.

University of Roehampton London

ID number:........

ETHICS COMMITTEE

PARTICIPANT CONSENT FORM

Title of Research Project: Rehearing music: schematic and veridical expectancy ratings in children and adults.

Brief Description of Research Project: Approx. 180 participants ranging from 6 year-olds to adults will listen to 4 short novel melodic sequences (lasting 5 minutes) on headphones. Participants will provide a rating in response by using a Continuous Response Measurement Apparatus (CReMA) - a touch sensitive controller connected by USB to a laptop. Participants are to return one week later to take part in an identical experiment. Requirements of the task will be explained in detail and practice runs will be given prior to commencement of the task. Participants and/or parents on behalf of their children will complete a short questionnaire requesting demographic information and music participation information. Completion of the rating task and the questionnaire is expected to take around 10 minutes. The second week of testing is expected to take around 5-10 minutes. During the experiment, participants will be filmed – this will be useful for checking in case of any discrepancies in the data. In addition, footage may be used for academic conferences and lectures. The research will take place in educational institutions around London and Birmingham.

Investigator Contact Details:

Hayley Trower
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Consent Statement: *(please delete as appropriate)*

I agree to take part in this research/ I agree for my child to take part in this research, and am aware that *I am/ my child is* free to withdraw at any point without giving a reason, although if I do so I understand that my data might still be used in a collated form . I understand that the information *I provide/ my child provides* will be treated in confidence by the investigator and that *my identity/ my child's identity* will be protected in the publication of any findings and that data will be collected and processed in accordance with the Data Protection Act 1998 and with the University's Data Protection Policy.

Name ....

Signature ....

Date ....

1

Please note: if you have a concern about any aspect of your participation or any other queries please raise this with the investigator. However, if you would like to contact an independent party please contact the Professor of Education and Philosophy and Head of Research (or if the researcher is a student you can also contact the Director of Studies.)

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Appendix F: Questionnaire I (adults)

Participant number: ....

Thank you for completing this questionnaire and taking part in today's study. Your responses and comments are very valuable.

1. Please indicate your gender

☐ Male ☐ Female ☐ Prefer not to say

2. Please specify your birth month and year

....

3. What is your nationality?

....

4. Have you ever had private instrumental tuition? (outside of school curriculum)

☐ Yes (For which instrument(s)? .... ☐ No *(please go straight to question 6)*

5. Please state how long you have had private instrumental tuition for

.... *years* .... *months*

6. Have you ever taught yourself to play an instrument?

☐ Yes (For which instrument(s)? .... ☐ No (*please go straight to question 9)*

7. Please state how long you have played a self-taught instrument for

.... *years* .... *months*

8. Please state how many hours per week you currently spend playing an instrument

Instrument 1............... *hours* .... *minutes*

Instrument 2............... *hours* .... *minutes*

Instrument 3............... *hours* .... *minutes*

Instrument 3............... *hours* .... *minutes*

9. What music do you currently enjoy listening to? *Please provide in detail, such as genres, particular artists, particular songs, music of a particular culture. If you* ***don't*** *enjoy listening to music, please state.*

....
....
....

10. How many hours per week do you spend listening to music (e.g. on an ipod, in the car, at home, at a concert)

.... *hours* .... *minutes*

11. On the following scales from 1 – 5, please indicate how you feel about the task you completed today

1	2	3	4	5
Not at all easy	Not that easy	Neutral	Fairly easy	Very easy

1	2	3	4	5
Not at all enjoyable	Not that enjoyable	Neutral	Fairly enjoyable	Very enjoyable

12. Do you have any comments?

....
....

Please provide your email address and name if you would like to be contacted for further research
Name ....
Email address ....

Appendix G: Questionnaire II (children)

University of Roehampton
London

Participant number: ....

Thank you for completing this questionnaire and taking part in today's study. Your responses and comments are very valuable. Answer all of the questions, and write N/A if any questions are not applicable.

1. Please indicate your gender

☐ Male ☐ Female

2. What is your date of birth?

....

3. What is your nationality?

....

4. Do you attend instrumental tuition at school? If yes, please state what instrument(s) you play

....

5. Please state how long you have attended instrumental tuition at school for

.... *years* .... *months*

6. Please state how many hours of instrumental tuition you attend per week at school

.... *hours* .... *minutes*

7. Do you attend instrumental tuition outside of school? If yes, please state what instrument(s) you play

....

8. Please state how long you have attended instrumental tuition outside of school for

.... *years* .... *months*

9. Please state how many hours of instrumental tuition outside of school you attend per week

.... *hours* .... *minutes*

10. How long do you spend practicing an instrument per week?

.... *hours* .... *minutes*

11. Do you listen to music? If yes, what music do you listen to? *Please provide as much detail as you can e.g. genres, particular artists, particular songs, music of a particular culture*

....
....
....

12. How many hours per week do you spend listening to music (e.g. on an ipod, in the car, at home, at a concert)

.... *hours* .... *minutes*

13. On the following scales from 1 – 5, please indicate how you feel about the task you completed today

1	2	3	4	5
Not at all easy	Not that easy	Neutral	Fairly easy	Very easy

1	2	3	4	5
Not at all enjoyable	Not that enjoyable	Neutral	Fairly enjoyable	Very enjoyable

14. Do you have any further comments?

....
....

Appendix H: Ethics statement

The research for this project was submitted for ethics consideration under the reference EDU/14 062 in the Department of Education and was approved under the procedures of the University of Roehampton's Ethics Committee on 04.03.14.

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